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Nineteen Hundred and Seven.

The business reaction which we, in common with other sober-minded critics, predicted last January in the days of 25-cent copper, has come. It has been blowing harder than was anticipated and larger. The causes for this are manifold and deep-seated. We were growing too fast, and as the Germans say, "a tree never grows quite to heaven." The volume of business increased steadily every year from 1904 to 1907. Every agency of production was overloaded. There is a point of maximum efficiency for any machine, and if it is speeded or loaded beyond this point the slight increase of production is accompanied by a great increase in the bill for fuel or repairs. It was so with our great industrial machine in the early months of 1907. Especially with the railroads, which were "overloaded" so much that their efficiency decreased. Then there was too rapid an increase of prices. Wages rose to beyond the point where labor was profitable to the employer at such prices for his product as the world could continue to pay. In addition to this, labor became in all industries, notably the mining and smelting industries of the West, indifferent and inefficient. A lack of trustworthy reliable men became evident. The quality of the immigrants from Southern Europe was inferior to those we had already received, and their ignorance of the English language made it difficult to turn them into reliable producers. At the same time, we were living at too expensive a rate, putting too large a proportion of our national income into automobiles and other non-productive outgoes. Large capital obligations were also incurred for meritorious enterprises, the return from which, though sure to come, was necessarily deferred for several years. An instance of this is the expenditure of \$15,000,000 in the copper mines of Ely, Nev., which will make no returns for several years after the first expenditure.

* * *

This increase of gross expenditure and diminution of net earnings and this commitment to large expenditures with deferred return—as the Gary plant of the Steel Corporation and the "St. Paul" extension—necessitated an expansion of credit and a borrowing from the future of sums which the future could well take care of, but which were not available in the present. The "entrepreneur" class owed too much, and when creditors began to call in loans and collateral must be sold, the offerings of securities were soon larger than the demand and a tremendous shrinkage in prices resulted at once. This narrowed the basis of credit, and it soon became impossible to float new enterprises and difficult to keep those already launched above water, for all enterprises until they have accumulated a great surplus, like Calumet and Hecla or the Standard Oil, must borrow money for development and extensions. This condition prevailed throughout the entire world, especially in Germany. At the very time this restriction became necessary, there existed a wide-spread, underlying feeling of

uneasiness even among sober-minded men. The discussion of socialistic doctrines in this country and Europe made many ask themselves, "Is our distribution of prosperity entirely just? May we not be on the verge of important changes in our ownership systems, not what the extremists demand, but something unforeseen but none the less radical?" The coincidence of a vague feeling of uncertainty and a contraction of credit after a period of expenditure resulted in a general loss of confidence. This was no doubt aggravated by the remembrance of the shocking disclosure of ignorance and selfish greed among the trustees of insurance funds in New York. Possibly some alarm was caused by the explosiveness of the President. Doubtless this was to a certain extent a contributing cause, and so was the great loss at San Francisco, but the underlying causes were, as first indicated, that we spent more than we earned for three or four years, and tried to do too much before we had saved the money to do it.

* * *

When stringency began, the lack of confidence in our trust companies and banks was intensified in its growth by the general feeling of uneasiness referred to, though it might well be that those who felt most profoundly that socialistic agitation meant something portentous were not at all the ones to yield to the monetary panic. A panic or a sense of alarm pervading a crowd is something the sociologists are unable to explain. The danger may be entirely imaginary. The crowd may be composed of individuals who have never seen one another. They may perhaps receive a common suggestion from the press or from some absurd rumors. They seem to communicate by sympathy. At all events the crowd appears and is entirely immeasurable. This condition of mind rarely lasts more than a short time, but while it lasts men are not themselves and may do incalculable damage. Society in a panic may be compared to an engine when the governor belt has broken and the engineer is afraid to shut the throttle. We have been perilously near such a condition for some weeks, but the emotional stress has evidently weakened. Now we must retrench, save and invert. The period of depression is the fruitful period to a nation. It is then that it grows rich. So rapid is our production that we need only to stop our sources of waste for three months and our surplus capital will clamor for outlet.

* * *

Strange as it may sound, we are after all in good financial condition to-day, that is in essentials. The production per capita of food products and metals was never so great before. Our expenditures in irrigation and other new enterprises are about to yield enormous returns. Our West is in sound condition, quite the reverse of 1893. If San Francisco is really relieved from the control of criminals and spoilers the fire loss is made up. We have the men and, above all, we are acquiring the science and experience needed in industry. In this alone we are many millions richer in power than we were ten years ago. The man who "goes short" on American prosperity because of a temporary setback will be a loser. It is risky to sell short an article that is practically inexhaustible. One can corner a thing only when the supply is limited. From this viewpoint, which appears the only logical one, we extend to all our friends our wishes for a prosperous year 1908.

The Status of Electrochemical Industries.

Probably the two most interesting electrochemical novelties of the past year were Mr. Acheson's colloidal ("deflocculated") graphite and Dr. Potter's silicon monoxide ("monox"). These two examples show clearly the possibilities and the difficulties which are before the electrochemical inventor—the possibilities of entering new and unexpected industrial fields and the difficulty of having to determine first in long research all the properties of a new material and then to find a market for it. While we, therefore, see the electrochemical industries grow and cover fields undreamed of ten years ago, it is clear that this growth to be sound must be slow and gradual. While the electrochemical inventor's work in the laboratory may be revolutionary, it can be transformed into commercial results only by slow evolution, following strictly the rules of logic. The evolution of the electrochemical industries along such logical lines is indeed the most characteristic feature of the development of the past year. Thus, in the iron and steel industry the manufacture of ferro-alloys has been steadily growing with the extension of the high-speed tool-steel production; besides continued imports of large quantities of ferro-alloys from Europe we have now a strong and rapidly yet quietly extending home industry. The use of the electric furnace for making high-grade steel also progresses steadily, especially in Europe, and it is characteristic that more attention is now being paid to the metallurgical side of the problem. The two articles of Prof. Wedding and Mr. Thallner in this issue are interesting indications of this fact. The electric furnace is no longer considered simply as a melting furnace, but the attention is now directed to the possibility of using special slags fluid at the high temperatures available and permitting a very complete purification of the metal. In the new year we will also witness the final completion of the Héroult electric pig iron plant of the Noble Electric Steel Co. in California, which is not less interesting because we have to do here with singularly special local conditions.

* * *

In the fixation of atmospheric nitrogen by means of electric discharges, the moving-arc method, instead of the old spark method, seems now to be universally preferred, and the problem appears to be solved in its chief technical features, but we have often pointed out that the commercial success of the Birkeland-Eyde process in Norway is essentially based on exceedingly low power prices. All the "old" electric furnace industries in this country have been flourishing during the past year and new companies are springing up. In the sodium-chloride electrolysis industry the fire of the Acker Process Co. works has removed the only process using a fused electrolyte from the field. The industry extends quietly wider and wider into the paper and pulp mill field and a kind of diaphragm cell (in the widest sense) seems to be generally preferred. The large copper refineries near New York have completed important extensions during the past year. It will be interesting to watch developments in the aluminium industry in view of the Bradley patent's expiration in 1909. The present sole producer certainly occupies now a formidable commercial position. Taken in the whole, the electrochemical industries have shown a sound, steady growth, which offers the brightest prospects for the future.

The Iron and Steel Industry in 1907.

Nothing could show a greater antithesis than a comparison of iron trade conditions at the beginning and at the close of the year 1907. The year opened with a strong demand for all classes of iron and steel, production being forced to the utmost, new blast furnaces and steel plants being rushed to completion, pig iron prices advancing and finished steel prices being held on the previous basis only by the conservatism of producers. The year closes with production at about one-third the maximum rate, demand extremely light, work suspended or being but leisurely prosecuted on new plant, pig iron prices down, and prices of finished steel products maintained only by the knowledge of producers that cutting would induce demoralization on account of the lack of consuming demand. The change in productive activity began in the closing days of October; until then there had been an almost steady increase in production, with the result that the October output of pig iron was the largest for any month in the history of the American iron trade. Then came, in but little over two months, a reduction in output of between 60 and 70 per cent. For a period of almost three years, or since the beginning of 1905, the productive resources of the country had been continuously strained, the steadily increasing output during this period being due to the completion of new furnaces and the harder driving of old furnaces. At all times Bessemer and open-hearth steel making capacity has been ample to refine the pig iron available, and there has easily been sufficient rolling capacity to take care of the ingot output, so that production of finished steel has been gaged by the supply of pig iron.

* * *

The decline in demand and production, beginning late in October, was simultaneous with a financial panic which has been unique in its suddenness and scope. The financial panic did not cause the slump in the iron and steel trade. It did slightly accentuate it, but had financial conditions remained easy there is absolutely no question that a general slowing down in the iron and steel industry would have occurred before the close of the year. All the developments of the preceding ten months had pointed clearly to such a slowing down. These evidences had arisen, in a comparatively small degree, through a tightness in the money market which was visible a year ago; but that was not a cause, since money is merely a medium and reflects conditions which are more fundamental. Encouraged by the guarantee of steady prices brought about by the formation and wise management of the United States Steel Corporation, railroads and other consumers were led to buy freely and anticipate requirements. Such a policy could not be pursued indefinitely, as there is a limit to the anticipation of requirements, no matter how free from trouble the future may appear to be. It was purely an incident that these heavy industrial operations caused a tightness of money; they were bound to slack off in any event, and had it been that industry was being conducted without the use of money or credit the tapering off would, nevertheless, have been inevitable. In our iron and steel market review last March this necessity was clearly outlined, the situation being gone over in detail, and the outlook summed up in the words: "The indications thus are, that while the greatest activity

should prevail for six or nine months to come, there will be some recession in demand late this year and in 1908." The program was carried out exactly, except that the financial panic precipitated almost the entire recession in demand upon the two closing months of the year. The "greatest activity" which was referred to prevailed for exactly six months from March 1.

* * *

That same review last March contained a full presentation of the increase in pig iron capacity and, as already noted, this is an index to the whole industry, since finishing capacity has always been ample. It had taxed the capacity in 1902 to make 17,821,307 gross tons of pig iron; in 1906 a similar taxing of the increased capacity resulted in an output of 25,307,191 tons. Then, referring to the calendar year 1907, it was said: "Through the progress of new erection it can be estimated, on quite complete data, that so far as physical considerations control, a production of 28,000,000 tons can be made. With the present trade outlook it is quite certain that no such tonnage can be absorbed, and a reaction in prices of pig iron is inevitable." A few figures will present a clear picture of what has occurred, these referring to gross tons of pig iron:

Production in 1906 in tons.....	25,307,191
Rate during first ten months, 1907.....	27,350,000
Rate during October.....	28,000,000
Estimated output, 1907.....	25,750,000
Approximate rate close of year.....	10,000,000
Capacity of furnaces completed in 1907.....	2,110,000
Capacity under construction, Jan. 1, 1908..	3,500,000

* * *

There have been scarcely any changes in prices of finished steel products during the year. Pig iron advanced until about June 1; thereafter there was a continued recession, at first only by the reduction of premiums for prompt iron, and afterwards by a general decline. The course of pig iron prices is illustrated by the ascertained average selling price of Bessemer pig iron each month, this average being compiled for the adjustment of certain contracts from actual sales. These disclose the prices at which pig iron was sold better than do current market quotations. It may be noted that foundry pig advanced to a somewhat higher level than Bessemer, and declined towards the close of the year to a lower level. The Bessemer average, f. o. b. valley furnace, has been as follows: January, \$22.07; February, \$21.93; March, \$22.05; April, \$21.36; May, \$23.28; June, \$23.25; July, \$22.41; August, \$22.00; September, \$22.00; October, \$21.89; November, \$19.75; December, \$19.00. In November, consumers notified mills to discontinue shipments on nearly all the contracts on books, except in cases where erection work could not conveniently be stopped; since then the curtailment in output has continued, there being scarcely any new business placed. The manufacturers have had frequent conferences, and have appointed a number of committees to canvass the situation, prevent demoralization in prices, and induce as great a curtailment in production as the state of trade calls for. Their efforts have thus far been successful, and what in the old alignment of the iron and steel trade would have produced a demoralized rout has resulted in nothing but an entirely orderly, although rapid, retreat, with the band playing the most stirring music.

Fluctuations of Metal Prices in 1907.

On page 40 of this issue we give some curves showing the fluctuations of the prices of metals during 1907. The curves show at a glance the development of the metal market during the past twelve months.

The iron curve refers to foundry iron No. 2 as most representative for the iron market, and is based on the *Iron Age* quotations for foundry No. 2, standard, Philadelphia. The ordinates represent dollars per gross ton.

All the other curves are based on the quotations of the *Engineering and Mining Journal*. The curve for electrolytic copper relates to New York quotations for electrolytic copper in cakes, ingots or wire bars.

The zinc curve is based on New York quotations for spelter, ordinary Western brands.

The lead curve is based up to the middle of November on the quotations of the American Smelting & Refining Co. for nearby shipments of desilverized lead in 50-ton lots or larger. At the middle of November the American Smelting & Refining Co. announced that it withdrew its official quotations and would compete in future in the open market. The end of the curve therefore is based on open market quotations.

The Iron and Steel Market.

The curtailment in iron and steel production, begun on such an enormous scale about Nov. 1, has been continued through December, and the year closes with a rate probably in the neighborhood of one-third the October rate. Actual production in the closing week of the year was probably well under the rate of one-third, but in a general statement of this sort regard must be had to the fact that at the holiday season there is always some closing, irrespective of market conditions.

It is difficult to find expressions adequate to describing the stagnation which has fallen upon the trade. There has been practically no business at all placed during December, and the relatively small proportion of orders upon which shipments were being made at the beginning of the month have been playing out, so that for the beginning of January there is scarcely any tonnage to be shipped.

It is usual to ascribe this sudden stoppage to financial conditions. Doubtless this has been a contributory cause, but the fundamental trouble has been more deep seated. Conditions have been shaping themselves for a long time for a period of recession in demand if not in prices. Demand had increased as productive capacity continued to increase until it could no longer keep pace, and the departure of these lines from each other has always been the signal in the American iron trade for a serious disturbance. It is rather an incident than a cause that the departure occurred at a time of financial panic.

The month of December has been taken up very largely with meetings and conferences of various interests, designed to prevent a demoralization in prices consequent upon an effort to induce business when there was no business to be had. It would be of no advantage to any of the interests involved for prices to be slaughtered at a time like this, and it is most fortunate that producers have been able, by a free interchange of thought, to prevent demoralization. There have been no serious declines in prices, and the time is approaching when by an orderly and dignified readjustment, where such may be actually required, the foundation can be laid for a resumption of buying.

The low point in production is undoubtedly reached at the first of the year, and whatever change now comes must be in the direction of an improvement. Even the more optimistic do not expect that improvement to be rapid. The large buyers, as a rule, must finance their purchases, and that may be difficult for a time. The general expectation is that buying will first be by the smaller interests whose trade is steady although the

individual orders are not large. Demand for tin plate, for instance, is improving, and full activity for the tin mills is promised within a very short time. The canning crops will not wait, and preparation must now be commenced for them.

An interesting feature of the readjustment in progress is that it appears likely to be accomplished without any general reduction in wages, such as was at the beginning of December regarded as well nigh inevitable. The United States Steel Corporation took the lead in this, as it does in most iron and steel matters, and about the middle of December decided that it would not reduce wages. The independents, outside of some concerns in the East, have been following the lead pretty generally. With no wage reductions, the expectations of buyers of lower prices undergo a material discount and confidence is enhanced.

PIG IRON.

A great many merchant furnaces blew out during December, and others are scheduled to go out the first week or fortnight in January. With a further curtailment in pig iron output by the steel interests, it seems that the rate of pig iron production in the country as a whole has either dropped below the 10,000,000-ton market before Jan. 1, or will pass below that mark in the first fortnight of the new year. During nearly the whole of October the rate was about 28,000,000 tons, the record in the history of the American iron trade. Pig iron has declined during December, but not enough business is being done at the close of the month to establish genuine market quotations in all cases. Southern pig iron has clearly declined to \$13, Birmingham, and it is possible that this price could be shaded. Bessemer iron is purely nominal at \$19, valley, the same figure quoted last month, but if there were important business in sight it is possible \$18 or lower could be done. Basic pig is \$17 to \$17.50, valley. Foundry iron has been available at \$16.50, or \$17, at most central Western furnaces.

STEEL.

The United States Steel Corporation has sold about 100,000 tons of sheet bars, for first half delivery, to the South Wales tin plate mills and sheet mills in Wales and the Midlands. The price realized is, of course, much below the domestic market, but it is regarded as advantageous to have the tonnage. Billet prices remain, by an informal understanding of the mills, at \$28, Pittsburg, for either Bessemer or open-hearth, but under the lead of the Carnegie Steel Co. sheet bars have been reduced from \$31 to \$29, Pittsburg. There has been practically no business done in the domestic market, but there seems to be no disposition on the part of producers to shade the recognized market prices.

FINISHED MATERIAL.

Deliveries are pretty well over to the steel car interests on the large mass of car orders on which they worked all year, nearly all this car business being cleared up, with no fresh business immediately in sight. Some structural business is being placed from time to time, and deliveries have been maintained on many jobs where the work was partly under way. There has been an improvement in tin plates, and mills are resuming. In sheets, business is rather light, but what there is calls for immediate delivery. Some mills are shading plates by \$2 a ton, but this does not cover the full range of widths and thicknesses. Sheets are being shaded more or less generally by \$1 to \$2 a ton. In wire products the market level is that which prevailed before the official advance of \$1 a ton on Sept. 3. Otherwise prices are as given below, these being the recognized quotations; some of these may be reduced slightly after the first of the year:

Structural shapes, \$1.70 per hundred pounds for beams and channels, 15 inches and under.

Plates, \$1.70 for tank quality.

Merchant steel bars, \$1.60, base, half extras.

Sheets, 28 gage, \$2.60 for black and \$3.75 for galvanized.

Tin plates, \$3.90 for 100-pound cokes.

Plain wire, \$1.90.

The Moissan Medal.

Shortly before Prof. Henri Moissan's lamentable death last year, the phenomenal importance of his life work was twice recognized, first by the bestowal of the Nobel prize, and, secondly, by his old students and scientific friends by a presenta-



IMPRINTS ON MOISSAN MEDAL.

tion of a medal to commemorate the twentieth anniversary of his work on fluorine.

A replica of this medal has just been sent to all subscribers, together with a beautifully illustrated account of the proceedings at the presentation of the medal to Prof. Moissan. The pictures are herewith reproduced.

The medal is a fine specimen of the engraver's art of M.



MOISSAN'S APPARATUS FOR THE ISOLATION OF FLUORINE.

Chaplain. The act of presentation was quite informal, only the Paris members of the committee being present. Two short addresses were made, one by Prof. Lebeau, who spoke for the students and friends of Moissan, the other by Dr. Chabrie, who represented the (Paris) Institute of Applied Chemistry. While the isolation of fluorine was the chief object of their remarks, the speakers naturally referred also to Moissan's high-temperature work with the electric furnace.

Prof. Moissan replied in a few words expressing his ap-

preciation of this kind remembrance of his scientific friends and old students.

By far most of the subscribers were, naturally, Frenchmen, though we also find a series of illustrious names from other countries. Among the subscribers from England were Lord



THE LATE HENRY MOISSAN.

Kelvin, Lord Rayleigh, Sir William Crookes, James Dewar and R. S. Hutton; from Germany, Hans Goldschmidt, Walter Nernst, J. H. van't Hoff, Emil Fischer, Boettiger and Landolt; from Switzerland, G. Lunge; from Denmark, Julius Thomsen. The only four American subscribers were C. A. Doremus, Ira Remsen, G. F. Kunz and F. Lengfeld.

The Perkin Medal.

The Perkin medal, which is to be awarded annually to a distinguished chemist residing in the United States, will be awarded for the first time this year. The official presentation of the medal will be made at the January meeting of the Society of Chemical Industry. While it is this society which has founded the medal, all other national chemical societies were represented in the committee which made the award at its meeting held at the Chemists' Club on Dec. 16. The committee voted unanimously to confer on Mr. J. B. Francis Herreshoff the honor of being the first Perkin medalist.

Mr. Herreshoff is one of the most prominent and successful chemical engineers. His connection with the General Chemical Co. and the Nichols Copper Co. enabled him to do highly important engineering work on many fields of chemical and metallurgical industries, as in electrolytic refining of copper and in the development of the contact process for making sulphuric acid. Of the many apparatus which he has devised the Herreshoff roasting furnace is probably best known to the general engineering public.

Lord Kelvin.

By Lord Kelvin's death the world has lost the most brilliant representative of the Victorian era in England, and one of the greatest scientists and engineers of all times and all countries.

He was both a scientist and an engineer, and the most notable general mission which he fulfilled was the introduction of science, exact mathematical science, into engineering.

William Thomson, born in 1824, was the son of James Thomson, professor of mathematics in Glasgow, early distinguished himself in applied mathematics, and at the age of only 22 years he was appointed to the chair of natural philosophy in Glasgow. When the first Atlantic cable was proposed he applied his mathematical skill to the solution of the engineering problems involved and was immensely successful. Queen Victoria knighted Thomson in 1886, and made him Lord Kelvin in 1892. There is no necessity to summarize here the immense work of his life; he was equally successful in his contributions to the mathematical theory of all branches of physics as in the design of a long series of instruments and apparatus, especially electro-magnetic measuring instruments.

Lord Kelvin was buried in Westminster Abbey on Dec. 23 in a grave at the foot of Sir Isaac Newton's monument, and close to the spot where about a quarter of a century ago Darwin was laid to rest. The inscription on the coffin reads as follows: "William Thomson, Baron Kelvin, of Largs, P. C., O. M., G. C. V. O., F. R. S., LL. D., D. C. L. Born June 26, 1824. Died Dec. 17, 1907."

CORRESPONDENCE

Detinning.

To Editor of the Electrochemical and Metallurgical Industry:

SIR:—I have just noted the letter of C. Offerhaus in your September number, 1907, concerning the detinning of scrap with dry chlorine gas.

It may be of interest to know that the writer saw this process in successful operation at the chemical works of W. H. Bower, Philadelphia, Pa., in the spring of 1898. Therefore, this process has not only been in use in Europe for a long time but also in this country for at least ten years.

WEST VIRGINIA UNIVERSITY.

F. L. KORTRIGHT

The First Electrolytic Chlorate Plant.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your November issue, page 440, you mentioned in a note on the cost of water-power, the plant of Vallorbe (Switzerland). As the former general manager at Vallorbe, I give the following particulars which may also be of interest:

The height of the fall is now about 78 meters, for a new hydraulic installation has been made which adds 8 meters. The power utilized is about 3,000 hp., or 2,200 electrical horsepower for electrolysis. The annual charges per horsepower are about \$7.00.

The output was in the beginning (1892) about 600 tons of chlorate of potash, then (1899) about 1,200 tons, now 1,800 tons, and could be easily increased to 2,200 tons, to the round figure of 1 ton per electrical horsepower-year. The cost of production (at the plant) for chlorate of potash packed in kegs was at first \$5.00 for 100 pounds, and is now about \$3.00. If interest, depreciation, etc., are included the cost is about \$4.00.

Under these circumstances the chlorate industry is very attractive and lucrative. The plant of Vallorbe was the first electrolytic chlorate works. Since its establishment in the nineties the works have been enlarged and the process has been improved in so many respects that it is now absolutely different from the original process.

The important conditions for successful manufacture are: First, the electrochemical process must give a good ampere-hour efficiency. Second, the electrolytic apparatus should be so

designed as to make the voltage and the cost of maintenance a minimum.

About three-fourths of the chlorate of potash produced at the plant of Vallorbe is sold in Russia, Japan, South Africa and foreign countries.

The principal consumers are the match and fireworks and explosive industries.

M. COULERU.

PARIS, FRANCE.

The Use of the Electric Furnace for Making Alloy Steels.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—The Héroult electric steel furnace has been sufficiently discussed in general, and it is hardly necessary to add anything to the statement that plants are now in operation and under construction capable of producing a hundred thousand tons or more of special grades of steel annually.

In view of the great progress, however, which is now being made in alloy steels it will probably be of interest to steel makers to know that remarkable results have been obtained lately in Europe in the production of alloy steels in the Héroult furnace. It is easy to see why the Héroult furnace is specially suitable for this purpose.

Metallurgists and experienced steel makers know that there is a considerable loss of ferro-alloys in oxidizing furnaces, due to the oxidation of the added element, and that the resulting oxides form solid particles and remain more or less distributed in the steel. A uniform metal cannot be obtained therefore, nor is the added element evenly and uniformly alloyed with the steel.

On the other hand, in the electric furnace of Héroult the metal bath is absolutely protected from the atmosphere, so that no reoxidation is possible. Further, there is a continuous and rapid circulation in the metal bath, and there being no danger from oxidation or loss, the liquid steel may remain in the electric furnace at any desired temperature for any length of time. The uniform distribution and thorough amalgamation of any addition, either in the form of ferros or otherwise, is thus readily obtained without any special or extra care, and with the greatest possible economy. In the case of alloy steels, as well as any other grades of steel made in the Héroult furnace, the finished product is always thoroughly homogeneous and absolutely free from oxide gases or slag.

If further progress is to be made in the production of alloy steels on an economical and commercial basis, the important question is to find the most suitable furnace that will do the business most economically on a large commercial scale, either in conjunction with oxidizing furnaces operating as a purifier and a non-oxidizing finishing furnace, or where large daily products of tonnage steel are concerned, in the form of a large steel mixer, as an adjunct to a battery of oxidizing furnaces.

The purifying and finishing process requires comparatively little time and little expense over the cost of the roughing down process in oxidizing furnaces, and Dr. Héroult states that for steel mixers, where less power is required for purifying purposes, the cost is almost compensated by the savings in the required quantity of ferro-alloys and other economies.

The Héroult electric furnace and process has ceased to be an experiment, and there is no doubt in my mind that it is the most ready means of solving the all-absorbing problem in the steel industry: how to improve the quality of the present product, in a way that is economical and commercially feasible. It is the only furnace that combines all the advantages of the air-tight crucible and all steel making oxidizing furnaces, without any of the disadvantages of either. It is absolutely protected from the atmosphere, like the crucible, and can handle large units of metal and subject same to metallurgical operations as freely and as easily as is being done to-day in any oxidizing furnaces known to me.

R. H. WOLFF.

NEW YORK CITY.

The Duplex Process for Steel Making.

BY PROF. HENRY M. HOWE.

If we are asked to state concisely the advantage of the duplex process which is to compensate for its disadvantage of complexity, must we not say that it is this in the last analysis; that it simplifies the conditions with which the composition of the pig iron has to comply, and thus lessens the danger of making "misfit" iron; i. e., that which is unsuited in composition to the process for which it was intended, and therefore presents us with the dilemma of either (1) using it in that process, though at a disadvantage, or else (2) using it in some other process or selling it; in either case only too often at a loss which may be serious, and of lacking the iron needed for the process which we wish to use.

The duplex process, in its most promising form, removes the silicon and part of the carbon of the pig iron in an acid Bessemer converter, and then removes the phosphorus and brings the steel accurately to the desired composition and temperature in a basic open hearth furnace to which the molten metal is transferred from the converter. How does this simplify the conditions with which the composition of the pig iron must comply? Pig iron for the acid Bessemer process must needs be low in sulphur, and its silicon content should be nearly constant, while that for the basic open hearth process should be as nearly as possible free from both silicon and sulphur. But these limitations are very difficult to comply with, because most of the conditions in the blast furnace which tend to restrict the sulphur-content tend to raise the silicon content. It is by relieving the blast furnace manager of these limitations that the duplex process may be of service.

The reason why the sulphur content of the pig iron for the acid Bessemer process should be small is that this process removes none of this most harmful impurity. The reason why the silicon-content should be nearly constant is, first, that it is essential to the making of sound steel of good quality that the temperature at which the process ends and at which the molten steel is cast should be exactly that aimed at; and, second, that variations in the silicon-content tend strongly to cause corresponding variations in the temperature of the process, for the very simple reason that here the combustion of silicon is the chief source of heat. It is true that the variations in silicon are greatly lessened by the use of the "mixer," and that the means of counteracting them are convenient and pretty effective. But, though the harm which they do is thus greatly lessened, it is not wholly done away with. But if, as in the duplex process, the Bessemer converter is relieved of the work of bringing the steel to the needed casting temperature, and has only to remove the bulk of the silicon and carbon without reference to the temperature, then the silicon content of the pig iron becomes relatively unimportant as regards the Bessemer end of the process.

The reason why the silicon-content should be small in pig iron for the basic open-hearth process is that the silica which results from the oxidation of the silicon not only corrodes the basic lining of the furnace, but also, by lessening the basicity of the slag, interferes with the removal of both phosphorus and sulphur, a most serious harm. The reason why the sulphur-content should be small is that the work of removing sulphur is both slow and costly. But if the silicon of the pig iron is removed by a preliminary treatment in a Bessemer converter, then the silicon-content of the pig iron as it issues from the blast furnace is a matter of indifference as regards the open-hearth end of the process, and we have already seen that it becomes of only minor importance for the Bessemer end.

With the silicon-content of the pig iron thus made rela-

tively unimportant, the work of desulphurizing in the blast furnace becomes at once easier and more thorough, because it is freed from the hampering need of simultaneously controlling the silicon-content.

If we look at the matter only from the point of view of the open-hearth process, the preliminary desilicidizing in the Bessemer converter may prove profitable; but whether it will prove more profitable than desilicidizing in a regeneratively heated mixer remains to be proved.

We naturally conjecture that, if there is but a moderate tendency to excessive silicon-content, then the mixer treatment should be the more profitable, because it would probably imply less loss of iron than the preliminary Bessemerizing. On the other hand, if the silicon-content is likely to be very excessive, then the Bessemerizing should be the better, because it should remove such a large excess of silicon more surely and easily than the mixer.

COLUMBIA UNIVERSITY, New York.

The Centennial of the Discovery of Sodium and Potassium.

On Nov. 19, 1807, Sir Humphry Davy, then 29 years old, delivered before the Royal Society, in London, a Bakerian lecture entitled "Some new phenomena of chemical changes produced by electricity, particularly the decomposition of the fixed alkalies, and the exhibition of the new substances which constitute their bases and on the general nature of alkaline bodies." The results described in this lecture had been obtained by Davy with the aid of the voltaic pile, discovered by Volta in 1800.



SIR HUMPHRY DAVY.

Davy first experimented with aqueous solutions of alkalies, but obtained, of course, on electrolysis only oxygen and hydrogen. On the supposition that the water interfered, he heated a platinum spoon, filled with potash, by directing a stream of oxygen on the flame of an alcohol lamp. The potash was thereby brought to red heat and was rendered perfectly fluid. The spoon was connected with the positive pole of a 100-plate voltaic pile, while a piece of wire, dipping into the potash, was the negative pole. There was "a most intense light" exhibited at the negative pole, and when the poles were changed this light always appeared at the negative pole. Davy concluded that a very inflammable substance was formed from the potash at the negative pole, but that its isolation did not succeed on account of his method of heating.

When, however, by using a sufficiently strong voltaic pile he succeeded in employing the electric current for both heating and electrolyzing potash (slightly moistened by exposure to air), "small globules having a high metallic lustre, and being precisely similar in visible character to quicksilver appeared." By cooling, a protective coating of potash formed around the potassium. Analogous experiments led to the isolation of sodium. With the small quantities of the metals thus produced Davy was able to determine their properties. The accompanying picture of Sir Humphry Davy is reproduced from our London contemporary *Electrical Engineering*.

How some eighty years later these processes were reduced to operation on a large scale by an American, Hamilton Young Castner, is recorded on page 121 of our Vol. I. We do not belittle Castner's magnificent and persistent work, by emphasizing the importance of Sir Humphry Davy's ingenious pioneer research, which has placed him forever in the front rank of chemical experimenters of all times. The Faraday Society rightly celebrated the centenary of Sir Humphry Davy's discovery in its meeting of Dec. 17 by an illustrated lecture of Dr. F. Mollwo Perkin.

Metallurgical Calculations.

By J. W. RICHARDS.

Professor of Metallurgy in Lehigh University.

The Metallurgy of Lead.—I.

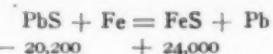
The extracting of lead from its ores and the refining of the crude metal to commercial lead, constitutes the metallurgy of lead. The chief ore is Galena, lead sulphide, PbS ; but the carbonate, Cerussite, $PbCO_3$, and the sulphate, Anglesite, $PbSO_4$, occur at some places in important quantities; the silicate, phosphate, molybdate, tungstate, chloride and native lead are rare minerals.

The reduction of the oxidized lead ores, such as often occur at the outcrops of sulphide veins, is very simple; carbon, the cheapest and most universal reducing agent, reduces them satisfactorily at a red heat, with some loss of lead by volatilization. The sulphide of lead, however, is not reducible by carbon; it requires other treatment. If we tabulate the most common sulphides according to their thermo-chemical heats of formation, expressed per unit weight of sulphur held in combination (32 kilograms), we find the common metals arranged as follows:

Calories.

Potassium (K, S).....	103,500
Calcium (Ca, S).....	94,300
Sodium (Na, S).....	89,300
Manganese (Mn, S).....	45,600
Zinc (Zn, S).....	43,000
Cadmium (Cd, S).....	34,400
Iron (Fe, S).....	24,000
Cobalt (Co, S).....	21,900
Copper (Cu, S).....	20,300
Lead (Pb, S).....	20,200
Nickel (Ni, S).....	19,500
Mercury (Hg, S).....	10,600
Hydrogen (H, S).....	4,800
Silver (Ag, S).....	3,000

A glance at this table shows us that some metals unite with sulphur more energetically than lead does, and others less energetically, and points to the theoretical possibility of decomposing lead sulphide by the agency of copper, cobalt, iron, cadmium, zinc, etc. Of these agents, iron is, of course, the cheapest and most available, and can be used to reduce lead sulphide with formation of iron sulphide.



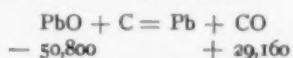
Showing an excess heat development, per 207 parts of lead set free, of $24,000 - 20,200 = 3,800$ Calories. If lead sulphide and iron are brought together at a red heat, at which heat the sulphide is molten, they react energetically with evolution of heat—enough theoretically to raise the temperature of the 207 kg. of lead and 88 kg. of iron sulphide some $280^\circ C$. The reaction is fairly complete if sufficient reducing agent is present and time is allowed, so that it can be used in assaying to determine lead by fire assay, but in commercial practice more or less undecomposed lead sulphide always remains in the iron sulphide, forming a sort of double sulphide or iron-lead matte.

It is interesting to note, *en passant*, that lead vigorously reduces silver sulphide, the liberated silver alloying with the excess of lead. This reaction is accompanied by a large evolution of heat, as the table shows, is the basis of the ordinary assaying methods for silver ores, and is used commercially to extract silver from its ores wherever lead is plentiful.

The affinity of lead for oxygen is a no less interesting subject, since it concerns not only the reduction of oxide ores but also the roasting of sulphide ores to oxide, and very largely controls the refining of impurities from lead by methods involving oxidation. The heat of combination of some of the more common elements with oxygen, expressed per unit weight of 16 kilograms of oxygen held in combination, is as follows:

	Calories.
Magnesium (Mg, O).....	143,400
Calcium (Ca, O).....	131,500
Aluminium $\frac{1}{3}(Al, O^3)$	130,870
Sodium (Na, O).....	100,900
Silicon $\frac{1}{2}(Si, O^2)$	98,000
Manganese (Mn, O).....	90,900
Zinc (Zn, O).....	84,800
Tin $\frac{1}{2}(Sn, O^2)$	70,650
Iron (Fe, O).....	65,700
Iron $\frac{1}{3}(Fe^2, O^3)$	65,200
Nickel (Ni, O).....	61,500
Hydrogen (H, O).....	58,060
Antimony $\frac{1}{3}(Sb^2, O^3)$	55,630
Arsenic $\frac{1}{3}(As^2, O^3)$	52,130
Lead (Pb, O).....	50,800
Carbon $\frac{1}{2}(C, O^2)$	48,600
Bismuth $\frac{1}{3}(Bi^2, O^3)$	46,400
Copper (Cu, O).....	43,800
Sulphur $\frac{1}{2}(S, O^2)$	34,630
Sulphur $\frac{1}{3}(S, O^3)$	30,630
Carbon (C, O).....	29,160
Mercury (Hg, O).....	21,500
Silver (Ag, O).....	7,000

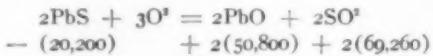
Reduction of Lead Oxide.—An inspection of above table shows that lead oxide is a weak oxide, weaker than the oxides of most of the common metals. It is reduced to metallic lead by many reagents with evolution of heat. It is also reduced by some weaker reagents with absorption of heat, provided that the oxide formed is gaseous and the necessary heat energy is supplied from outside. For instance,



Involves an absorption of 21,640 Calories, or several times as much heat as is necessary to raise the reacting substances, PbO and C, to the reacting temperature, a red heat. The reaction is endothermic, absorbing heat, and therefore only progresses in measure as the necessary calories are supplied from outside. The fact that all the substances concerned are liquid or solid except the product CO, gives a predisposing cause which facilitates the reaction, that is, the reaction can

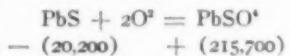
only go one way, since the CO gas escapes from the sphere of action as soon as formed.

Oxidation of Lead Sulphide.—When PbS is roasted, that is, heated to redness with free access of air, both the sulphur and the lead tend to oxidize, generating a large heat of oxidation, against which there is absorbed only the comparatively feeble heat of decomposition of PbS. The equation may be discussed as



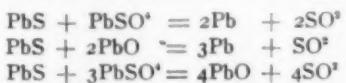
The net heat evolved in the equation is $240,120 - 40,400 = 199,720$ Calories, which is 33,290 Calories per unit weight (16 kg.) of oxygen used, or 418 Calories for each kilogram of lead sulphide oxidized. This great heat of oxidation, evolved in roasting, is quite sufficient, in fact more than sufficient, to provide the heat required for self-roasting without the use of any other fuel, the chief difficulty is really to keep the charge from getting too hot and melting everything down to a liquid before the roasting is anywhere near complete. In the ordinary hand-worked reverberatory roaster, the oxidation is so slow that the fire on the grate really controls the temperature on the hearth, and the temperature of the roasting ore can be regulated accordingly. Where the roasting is done quickly, by an air blast, as in "Pot Roasting," the temperature is kept down somewhat by previously roasting off part of the sulphur, or by liberally wetting the charge, or by using limestone in with the ore, to absorb by its decomposition into CaO and CO² a large part of the excess heat—while the melting down of the charge is prevented by the mechanical interference presented by intermixed, inert and infusible material, such as silica, lime, etc., which simply prevents the really melted globules of sulphide from running together and thus melting down to a liquid mass.

An interesting variation is the roasting of lead sulphide to sulphate; some of this always forms, due to the high formation heat and difficult decomposability of the sulphate.

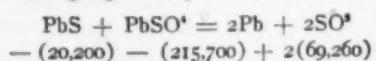


The net heat evolved is $215,700 - 20,200 = 195,500$ Calories, or 48,875 Calories per unit weight (16 kg.) of oxygen used, or 818 Calories for every kilogram of lead sulphide so oxidized. This is a high heat of oxidation, and explains the great tendency to form sulphate observed during roasting. If the conditions could be found whereby only this reaction occurred, the sulphate roasting could be easily made automatic without outside fuel. There is needed, at the present time, a careful laboratory investigation of the conditions, mechanical, physical, chemical and thermal, for the roast exclusively to sulphate—just as a bit of badly needed metallurgical information.

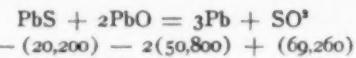
Double Reactions.—A large part in the metallurgy of lead is played by double reactions, such as the following:



On roasting lead sulphide for a short time, either lead or lead sulphate or mixtures of these are formed, according to the temperature and excess of air provided. With large excess of air and low temperature, and especially in presence of infusible materials which act as catalysts (i. e., which promote the union of SO² with O, and consequent formation of SO² and PbSO⁴), sulphate may be formed almost exclusively. If the temperature is then raised, the tendency of PbSO⁴ to react upon the undecomposed PbS rapidly gets stronger, until at an orange heat this takes place rapidly and fairly completely, forming the one single gaseous product, SO².



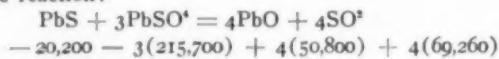
Net deficit, 97,380 Calories.



Net deficit, 52,540 Calories.

In both these cases the well-known phenomena of an endothermic reaction are manifest—the high temperature and strong firing necessary, and the formation of a single gaseous product from non-gaseous materials, assisting the reaction.

The reaction:



Net deficit, 187,060 Calories.

is supposed to take place in "pot roasting" where excess of air is blown through the finely divided material, but it is too endothermic a reaction to take place in a pot-roasting operation to more than a very subsidiary extent.

Oxidation Refining.—Impure lead is refined or "softened" by oxidation at a red heat. We must expect a great deal of lead to be oxidized in this operation, simply because of its preponderating mass, but the impurities present will oxidize relatively faster or slower than lead in proportion as their affinity for oxygen is relatively greater or less. The skimmings or slags obtained during softening are always principally composed of lead oxide, PbO, but they come off containing, in order, zinc, tin, antimony, arsenic, bismuth and small quantities of silver. During cupellation down to silver, which is continued oxidation until all the lead is oxidized, bismuth oxide is concentrated in the last parts of lead oxide formed, which may also carry silver in small amount; before this happens, however, the lithage formed is almost chemically pure.

The converse of these oxidation reactions also holds, viz.: differential reduction. Taking a softening skimming rich in antimony, for instance, it is possible by mixing it with a small amount of reducing agent, such as carbon, to reduce out of it all the silver and considerable of the lead which it contains without reducing much antimony. This leaves the remaining un-reduced material desilverized and poorer in lead, or richer in antimony, and on subsequent reduction of this by excess of reducing agent a rich antimony-lead alloy is obtained. The easy reducibility of lead oxide is complementary to the slow oxidation of lead; both facts are clear from the heat of formation of the various metallic oxides, and both are extensively utilized in the metallurgy of lead.

THE VOLATILITY OF LEAD.

The melting point of lead is 320°, its mean specific heat in the solid state 0.02925 + 0.000019t, heat in melted lead at its melting point 11.6 Calories, latent heat of fusion 4.0 Calories, heat in just melted lead 15.6 Calories, specific heat in the liquid state 0.042—and approximately constant—boiling point at normal atmospheric pressure about 1,800° C., latent heat of vaporization, calculated by Trouton's rule (23 T) 47.680 Calories per molecular weight = 230 Calories per kilogram, assuming the vapor monatomic, specific gravity of vapor 103.5, referred to hydrogen gas at the same temperature and pressure, or, theoretically, 9.315 kg. per cubic meter at 0° C. and 760 mm. pressure, as a standard datum.

The question of the volatility of lead at other temperatures than 1,800° C. is highly important in the smelting of lead ores, yet is practically an unknown datum. The following is an attempt to calculate these data, so important in practical metallurgy:

The vapor tension curve of mercury is known for very low and up to comparatively high pressures. A rule has been observed between mercury and water vapor, in that the absolute temperatures at which these two substances have the same vapor tensions are found to stand in the ratio 1.7 to 1 through a large range of temperatures. Since lead vapor is in all probability monatomic, like mercury vapor, we will deduce the vapor tension curve of lead from that of mercury, using the constant ratio derived from the two temperatures at which their respective vapors have atmospheric tension, viz.:

$$\frac{T_{Pb}}{T_{Hg}} = \frac{1,800 + 273}{357 + 273} = \frac{2,073}{630} = 3.3$$

The following table gives the most reliable data for the vapor tension curve of mercury, and the corresponding data calculated for lead, assuming the constant ratio 3.3 between the absolute temperatures at which they have the same vapor tension:

Tension of Vapor mm. of Hg.	Mercury °C.	Lead °C.
0.0002	0	625
0.004	33	735
0.045	67	844
0.28	100	954
1.47	133	1,064
5.73	167	1,173
18.25	200	1,283
50.	233	1,393
106.	267	1,502
242.	300	1,612
484. <i>Atmospheres.</i>	333	1,722
760. = 1.0	357	1,800
849. = 1.1	367	1,841
1588. = 2.1	400	1,951
	4.3	2,116
	8.0	2,280
	13.8	2,445
	22.3	2,609
	34.	2,774
	50.	2,938
	72.	3,103
	102.	3,267
	137.5	3,436
	162.	3,525

From the above table a vapor pressure curve of mercury and lead can be constructed. An examination of the data shows that lead is certainly volatile to a minute extent at a low red heat, and that a current of inert gas passing across the surface of melted lead at that temperature certainly carries away vapor of lead; at the melting point of silver the tension is only about one-quarter of a millimeter, or one three thousandth of an atmosphere, yet this means that each cubic meter of inert gas carries off one three thousandth of its volume, or one-thirtieth of 1 per cent of its volume, of lead vapor. At 1,300°, the temperature of a commercial zinc retort, or of a lead smelting furnace, the tension is about one-fortieth of an atmosphere, which would mean that any other gas or vapor could carry 2.5 per cent of its volume of lead vapor with it. It must be remembered, moreover, that such gas saturated with lead vapor if suddenly cooled does not deposit its excess of lead vapor as liquid lead, but that a suspension similar to hoarfrost almost inevitably results, the so-called "lead fume," which is simply molecularly divided liquid or solid lead carried in suspension by a current of gas. The lead vapor is thus almost entirely carried out of the furnace without condensation and deposition.

Looking at the higher pressures, we can understand why an explosive reaction results when PbO is reduced by finely divided aluminium, the "aluminothermic" reaction. The immense heat liberated in the reaction,



220,000 Calories, raises the products to an electric furnace temperature, to some 3,000° C., at which temperature the lead vapor has a maximum tension, according to our table, of 60 atmospheres. No wonder, then, that when Tissier tried this test for the first time, in 1857, using a piece of sheet aluminium weighing less than 3 grams (0.1 ounce), "le creuset a été brisé en mille pièces et les portes du fourneau projetées au loin"—the crucible was broken into a thousand pieces and the doors of the furnace blown to a distance.

A Modification of the Induction Furnace for Steel Refining.

We have noticed repeatedly in our columns the work which has been done with the electric induction furnace for steel refining on the Roehling iron and steel works in Voelklingen, Germany (our Vol. V., pp. 92 and 172). In *Stahl und Eisen* of Nov. 6, Geheimrat Prof. H. WEDDING describes a new development in the design of the induction furnace due to Messrs. H. ROEHLING and RODENHAUSER. This furnace is intended to refine molten steel received from the basic lined converter and to produce in continuous operation soft iron which is at least equivalent to Swedish soft iron. Prof. Wedding and others had an opportunity to see the furnace in operation. During this inspection heats of very different character were made. According to the desires of the visitors sometimes a very hard, sometimes a very soft and sometimes medium hard steel was made and cast into molds of different forms. In all cases the steel from the basic lined converter was the starting

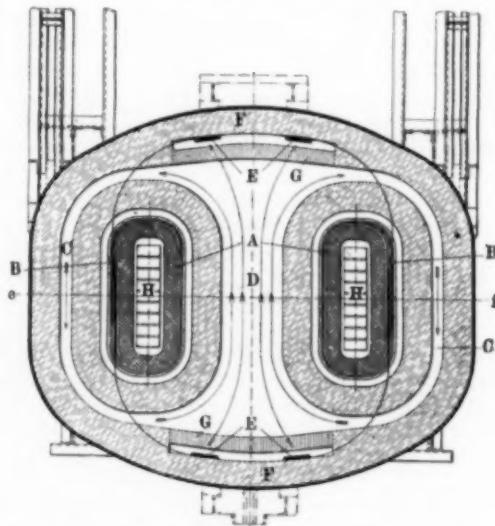


FIG. 1.—HORIZONTAL SECTION OF ROEHLING-RODENHAUSER FURNACE

material. It was supplied to the electric furnace in molten form, and was not only decarburized but also deoxidized and recarburized, that is, a soft steel as used for structural purposes, etc.

The chief new feature of the Roehling-Rodenhauser furnace, which distinguishes it from the Colby-Kjellin design, is that it combines two methods of electric heating; first, the ordinary heating by electric induction currents, while the second kind of heating also employs induction currents, which, however, are introduced into the molten bath through metal plates, called electrodes. This second method of heating has, therefore, some similarity with ordinary alternating-current resistance furnace practice.

The furnace is shown in Figs. 1, 2 and 3. Fig. 1 is a horizontal section along the line a b of Fig. 3. Fig. 2 is a vertical section along the line c d of Fig. 3, while Fig. 3 is a vertical section along the line e f of Fig. 1. The furnace is designed for a 5-ton charge, to be operated at 5,000 volts with a frequency of 15 periods per second.

Like the ordinary induction furnace, this furnace is essentially a transformer with a single primary winding A around both iron cores H of the transformer. The secondaries are two in number, one is the molten bath C in form of a ∞ , the channel D between the two cores being very broad. The other secondary is the copper winding B, which is connected with the metal plates E. These metal plates are inserted into the furnace walls F in such a way that the currents pass from the

winding B through the plates E, and through the mass G of highly refractory electrolytic conductors (of the same nature as used as filaments in the Nernst lamp) to the molten mass D. In this way the molten mass D is subjected to a double heating effect, one direct by induction and the other from the currents passing between the opposite sets of electrodes E. The direction of the currents in the bath at a certain moment is indicated by arrows in the illustration.

In order to protect the windings against the effect of high temperatures, thin-walled copper cylinders M M (Fig. 3) are provided, through which is conducted an air blast passing out of the tubes N₁, N₂. The transformer iron contains ventilation slits H (Fig. 1). These methods of cooling have been found to be perfectly sufficient during several months operation.

The charging door is at one end of the furnace, the tapping door at the other end. On account of the method of operation of the furnace the molten charge is kept in sufficient circulation so that all manual operations are restricted to taking care of the right formation of slag and to the tapping of the slag. As shown in Fig. 2 the whole furnace is built as a tilting furnace. In its general design the furnace is built very much like a Siemens-Martin open-hearth furnace.

The normal charge is 3 to 3½ tons, but about 800 kg. are left at the end of a heat in the furnace, so that the new charge consists of only 2½ tons. This is being done in order to keep the furnace hot, when after the conclusion of heat no fresh charge is yet ready for introduction from the converter in the electric furnace.

The operation of the furnace is as follows: After providing a basic lining of magnesia with 10 to 12 per cent tar of the hearth and around the transformer cores (the arch consisting of fire-brick), the inside of the furnace is first strongly heated. For this purpose rings of soft steel are placed in the furnace, which are heated to 900° to 950° C. by induction currents. As soon as the furnace stops to give off smoke (the hydrocarbons from the tar having been given off), fluid pig iron is introduced from the blast furnace. The electric circuit is then closed and the temperature begins to rise slowly. After 18 hours the furnace is up to full heat and there is no longer any smoke.

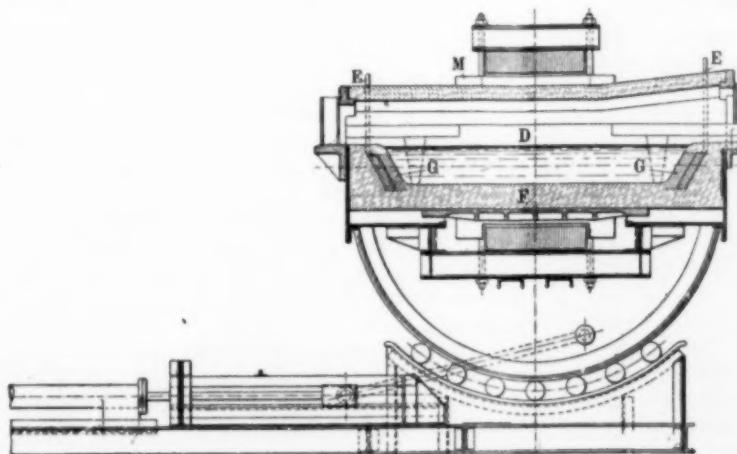


FIG. 2.—VERTICAL SECTION OF ROECHLING-RODENHAUSER FURNACE.

The molten pig iron is then removed by tilting the furnace, only 800 kilograms remaining back, and now the finished steel from the basic converter is introduced. Burnt lime is placed on this bath. The lime used contains 6 per cent magnesia. About 8 kilograms of fluorspar are added to get a sufficient degree of fluidity in view of the comparatively high content of magnesia. Refining now begins. If the slag becomes too fluid, lime is added; if too thick, fluorspar.

The operation is completed when no longer bubbles rise up from the liquid bath, and when samples taken from the

bath give satisfactory tests. The slag, which contains generally 25 per cent of iron in form of oxides, is removed, and a pure lime slag is formed from fresh burned lime and fluorspar and deoxidation begins now by means of ferro-silicon. Samples are taken again and tested. If the intention is to make high-carbon steel, powdered coke is added to the furnace, which quickly dissolves in the bath, otherwise spiegel-eisen is added as usual.

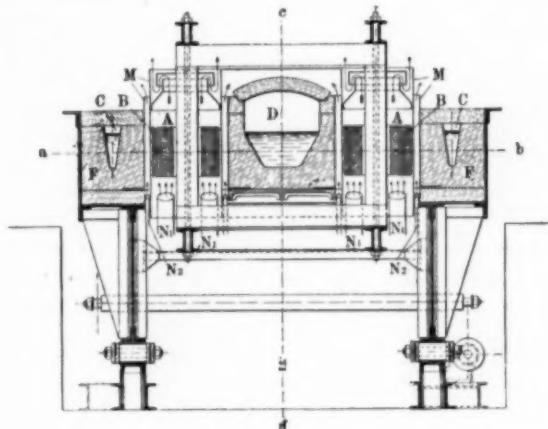


FIG. 3.—VERTICAL SECTION OF ROECHLING-RODENHAUSER FURNACE.

The final slag has the following composition:

	Per Cent.	Per Cent.	
FeO	5.32	Fe ₂ O ₃	0.94
MnO	0.9	Al ₂ O ₃	1.27
CaO	67.82	MgO	3.88
SiO ₂	0.97	P ₂ O ₅	0.6
S	0.9		

The alumina comes evidently from the fire-brick of the arch.

To make hard steel free from sulphur the steel must be left in the furnace for a longer time, and the sulphur must be removed by oxidation or manganese and a suitable fluid slag.

As analyses show, the sulphur may be completely removed in that way. Very small quantities of manganese are sufficient, but it is necessary to employ a high temperature, which can be accomplished easily by raising the voltage.

Compared with converter steel the electric steel when being cast runs exceedingly quiet, which is due to the fact that the steel has a very high temperature during casting.

With the electric furnace it is possible to remove completely all impurities from the steel. If the object is to bring the content of phosphorus below 0.02 per cent it is necessary to remove the second slag and form another third slag like the second. If the content of silicon has become too high it is easy to reduce it again by an addition of "Walzsinter," lime and fluorspar.

A complete removal of silicon should, however, not be attempted, because otherwise the iron does not get sufficiently dense in the mold. In spite of a content of 0.085 per cent silicon with 0.47 per cent manganese, a very quietly running and thoroughly dense steel is obtained when the content of carbon is only 0.01 per cent. An analysis showed in such a steel 0.03 per cent of phosphorus and 0.77 per cent of sulphur.

Each heat lasts in general for 2 to 3 hours. Two men are sufficient to do the work at the furnace while a third man attends to the electrical equipment. During tapping the circuit is broken so that the current, e. m. f. and power become zero.

Otherwise they remain practically constant during operation and are regulated only if for some purpose it is intended to raise or reduce the temperature. The conditions during a heat which begin at 10.50 A. M. is given in the following table:

Hours.	Minutes.	Volts.	Amperes.	Kilowatts.
10	50	2,600	145	330
11	00	2,800	150	365
11	10	3,000	165	430
11	20	3,000	165	430
11	30	3,200	170	460
11	40	2,800	152	375
11	50	2,600	142.5	315
12	00	2,000	142	330
12	10	2,400	128	250
12	20	2,400	130	270
12	30	2,400	131	210
12	40	2,400	131	210

Tapping was then begun, and after a new charge had been introduced the conditions were as follows:

Hours.	Minutes.	Volts.	Amperes.	Kilowatts.
12	55	2,600	40	80
1	00	2,600	130	310

The above figures show that the power factor is quite satisfactory. At 2,600 volts with a current of 145 amps, the volt amperes were 377,000, or 377-kv. amperes, while the kilowatts were 330. The power factor (or the cosine of the phase difference between e. m. f. and current) was therefore 0.875. Several analyses and results of mechanical tests are given.

Concerning the cost of the process, figures are given for a 5-ton furnace, and it is found that the total cost of refining 1 ton of soft steel in the electric furnace (including interest and amortization, but not including license fee) is \$5.83.

The final conclusions of Prof. Wedding are as follows: "This process, like other electric steel processes, serves simply for refining. It enables one to remove the last impurities from the steel and to introduce any amount of carbon and other elements. Above all things the electric furnace is a substitute for the crucible process by removing all gases, but has not the disadvantage of the crucible process, namely, the absorption of silicon from the crucible walls. If the product is worth about \$6.00 more per ton than the converter steel which is introduced into the furnace, the process is economical on a large scale. That the product is worth so much more must be concluded from the denser structure which manifests itself at the very high temperature, and which has an influence on the condition of the carbon that still remains to be investigated.

Dry Blast at Pottstown.

As noticed in our Vol. V., page 290, the Warwick furnace No. 2, at Pottstown, Pa., has been equipped for running with dried blast by the Gayley system. From the records of Mr. E. F. Cook and his engineers it is evident that the installation has proven very successful. By comparison of the operation of the furnace with natural air blast and with dried air blast, it appears that the introduction of the dry blast system has resulted in an increase of 5 per cent in the output and a decrease of 11.7 per cent in the consumption of coke per ton of iron. But this is not all.

The furnace was about to be blown out at the end of August, but since the dry blast installation had then been finished it was hoped that the new method would prolong the life of the furnace for a time sufficient to finish certain urgent contracts for basic iron. This has proved true, and it is estimated that the life of a lining is prolonged by 32 per cent by the dry blast method. Moreover, it was found that an unexpectedly high increase in percentage of the desired grade of metal was obtainable with the new process.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.

By PROF. BARON HANS JÜPTNER VON JONSTORFF.

(Concluded from Vol. V., p. 502.)

III.

We will now employ the views obtained in the previous chapters to the consideration of blast-furnace practice.

In the lower part of the blast furnace the oxygen of the air acts on the FeO, the coke and the metallic iron. The temperature at the tuyere level is, according to Le Chatelier, about 2,200° absolute; the blast is at a pressure of a little over 1 atmosphere. We can take it here for simplicity = 1 atmosphere. The tension of dissociation of FeO is at this temperature 0.05 atmosphere ($\log [O_2] = -1.3054$), whilst that of iron oxide is much greater. Since the oxygen pressure of the blast is 0.2 atmosphere ($\log [O_2] = -0.6990$), the iron in front of the tuyeres can still be oxidized. On the other hand, we have for the dissociation pressure of CO at this temperature:

$$\log [O_2]_{CO} = -9.2099 - 2 \log [CO];$$

and for that of carbonic acid:

$$\log [O_2]_{CO_2} = -3.0894 - \log [CO_2].$$

Both will become larger than that of FeO if the partial pressure of the CO should be under 0.0001 atmosphere, but that of CO_2 under 0.01 atmosphere, which, however, for CO need not be considered in the case of the blast furnace. Consequently, the oxygen of the blast can only oxidize the carbon, and not in any way the reduced iron.

We have thus in this zone only to take into consideration the influence of the oxygen of the blast and the FeO upon the fuel.

If there is, as in the normal working of the furnace, no more FeO present, the reactions of the furnace are the same as in an ordinary producer, in which the temperature, of course, is extremely high. Therefore, only CO can be formed, and the maximum pressure of this is 0.347 atmosphere.¹

Moreover, since the moisture of the air acts in an oxidizing manner on the coal, whereby hydrogen, and possibly hydrocarbons, are formed, this CO pressure must become even still smaller. (We will, however, here, for the sake of simplicity, neglect this influence of water vapor.) In accordance herewith most furnace gases show, as a matter of fact, when taken at this horizontal position in the furnace, or at a little above it, a percentage of CO of less than 34.7 per cent by volume, which proves that in the furnace zone we are considering no more FeO is present. If it were so, then by the comparison of the CO and CO_2 a not inconsiderable tension of dissociation of the FeO of this oxidizing effect must react on the coal, and "direct reduction" takes place. By this an increase of the percentage of CO and of the counter pressure in the blast furnace will take place. But the formation of carbonic acid in this part of the furnace, assuming equilibrium, can only take place if higher oxides of iron, with sufficiently large tensions of dissociation, are present.

Such cases, as a matter of fact, have often been observed, and show that FeO, or a higher oxide, was present. They would be specially observable if from any cause the oxidizing influence of the blast should be weakened.

During the tapping the blast is taken off; there is, therefore, only the influence of any FeO, etc., present on the fuel, and a sample of gas at this period, which was taken at the tuyere level of a blast furnace, contained

¹ 0.21 vol. of oxygen in the blast gives 0.42 vol. CO.
The nitrogen therewith is 0.79

The percentage of CO is therefore $42/1.21 = 34.7$.

	Before Tapping.	After Tapping.
	Per Cent.	Per Cent.
Nitrogen	67.70	57.56
Carbonic acid	1.19	2.96
Carbonic oxide	29.33	38.22
Hydrogen	1.62	1.17
Methane	0.03	0.09

Before tapping, the percentage of carbonic oxide is under 34.7 per cent, but the appearance of carbonic acid shows that at the temperature prevailing at the tuyere level, in the case of the equilibrium for the system air + coal, the possible existence of FeO , or even of Fe_3O_4 , is impossible. After tapping, on the contrary, the percentage of carbonic acid increases to more than double, and, moreover, the percentage of carbonic oxide considerably exceeds the value of 34.7 per cent.

Since the gas stream is going off through the furnace shaft with considerable velocity, the influence of the blast under the tuyeres (for example, in the tymp) will be less noticed. The influence of direct reduction must here also be clearly shown. Consequently, there was found in this part of the furnace the following composition of gas:

Blast Furnace at Vienne.

	Per Cent.
Nitrogen	61.07
Carbonic acid	0.68
Carbonic oxide	36.84
Hydrogen	1.41

Blast Furnace at Hasselfors.

	Per Cent.
Nitrogen	20.8
Carbonic acid	1.4
Carbonic oxide	75.9
Hydrogen	1.9

Blast Furnace at Forssjö.

	Per Cent.
Nitrogen	60.3
Carbonic acid	1.4
Carbonic oxide	36.7
Hydrogen	1.6

Blast Furnace at Hammarby.

	Per Cent.
Nitrogen	60.2
Carbonic acid	0.5
Carbonic oxide	37.6
Hydrogen	1.7

Blast Furnace at Clerval.

	1841.	1848.	Per Cent.	Per Cent.
Nitrogen	47.40	58.17		
Carbonic acid	.....	0.93		
Carbonic oxide	51.35	39.86		
Methane	1.25	0.25		
Hydrogen	.....	0.79		

With larger hearths the oxidizing influence of the blast opposite the tuyeres must be less, and therefore that of any iron oxide still present be clearly shown. Thus Ebelmen found in the blast furnace at Audicourt at this place: *Per Cent.*

	Per Cent.
Nitrogen	50.58
Carbonic acid	.....
Carbonic oxide	48.52
Hydrogen	0.90

³ That here, moreover, the equilibrium would not be reached in both cases, is shown by the calculation of the log of the tension of dissociation.

	Before Tapping.	After Tapping.
$\log [O_2] CO$	- 8.7354	- 8.8504
$\log [O_2] CO_2 = CO + O$	+ 2.5351	+ 1.7735
$\log [O_2] CO_2 = C + O_2$	- 2.0338	- 3.3296
$\log [O_2] FeO$	- 1.9880	- 1.9880
$\log [O_2] Fe_3O_4 = 3FeO + O$	+ 3.4248	+ 3.4248
$\log [O_2] Fe_3O_4 = 3Fe + 2O_2$	- 0.6311	- 0.6311

Temperature of furnace = 1,700° C., or nearly 2,000° absolute. These figures show, moreover, that higher oxides of iron must be present.

As the stream of gas ascends its temperature decreases, and, therefore, also the oxygen dissociation pressure of the FeO , as well as that of the carbonic oxide and carbonic acid. So long as the oxygen pressure of the reaction $CO_2 = CO + O$ remains greater than the tension of dissociation of the ferrous oxide, the carbonic oxide can exercise no reducing influence on the latter, whilst direct reduction will always be noticed. This shows itself from the fact that the CO percentage of the gas above the tuyere level is also still greater than 34.7 per cent, as, for example, in the blast furnace at Alfretton, 0.64 meter above the tuyeres.

	Per Cent.
Nitrogen	58.05
Carbonic acid	.....
Carbonic oxide	37.43
Hydrogen	3.18
Cyanogen	1.34

Or at one at Audicourt, 2.5 meters above the tuyeres:

	Per Cent.
Nitrogen	61.61
Carbonic acid	0.21
Carbonic oxide	36.38
Hydrogen	1.79

Or at the blast furnace at Clerval:

	1.05 m.	3.6 m.	Above the Tuyeres.
	Per Cent.	Per Cent.	Per Cent.
Nitrogen	61.22	63.06	63.04
Carbonic acid	0.07	0.49	.....
Carbonic oxide	37.55	35.47	35.05
Methane	0.10	0.31	0.36
Hydrogen	1.13	1.09	1.06

So also the increase in the percentage of carbonic oxide in the gas with the increasing height above the tuyeres is shown in the following examples:

Above tuyeres.	Blast Furnace at Forssjö			Pont l'Evêque		
	2.51 m.	3.69 m.	5.06 m.	0.24 m.	0.29 m.	0.67 m.
	%	%	%	%	%	%
Nitrogen	62.4	62.1	61.2	75.10	71.20	62.70
Carbonic acid	3.2	2.2	2.9	8.11	5.86	0.16
Carbonic oxide	32.0	33.7	34.9	16.53	22.25	36.15
Hydrogen	2.4	2.0	1.0	0.26	0.68	0.99

If in the upper parts of the blast furnace the temperature has sunk so far that the oxygen pressure of the reaction CO_2 (equal to $CO + O$) is smaller than the tension of dissociation of FeO , the reduction is effected by carbonic oxide, whereby the percentage of carbonic oxide in the gas is lowered whilst the carbonic acid increases. Thus, for example, Ebelmen found:

	Blast furnace at Seraing.					
	0.72 m.	10.77 m.	11.38 m.	11.69 m.	13.21 m.	14.18 m.
	%	%	%	%	%	%
Nitrogen	54.63	61.34	61.15	62.46	59.64	57.06
Carbonic acid	.....	0.10	1.13	1.54	9.85	11.39
Carbonic oxide	45.05	36.30	35.35	33.88	28.06	28.61
Methane	0.07	0.25	0.29	1.43	1.48	0.20
Hydrogen	0.25	2.01	2.08	0.69	0.97	2.74

Finally the gas in the upper parts of the furnace comes into contact with iron in a higher oxidized condition and reduces this to FeO , because the tension of dissociation of Fe_3O_4 to $3FeO + O$ is very high.³

Moreover, at a lower temperature the tension of dissociation of carbonic oxide can be greater than that of carbonic acid, and then the breaking up of $2CO$ into $CO_2 + C$ takes place. But

³ Under certain conditions, as mentioned above, an oxidation of FeO can take place, by means of which perhaps certain irregularities which are found in the analysis of furnace gases from furnaces of varying cross-section may be explained. Thus at 800° absolute the oxygen pressure of the reaction $Fe_3O_4 = 3FeO + O$ is smaller than the tension of dissociation of FeO . Below this temperature an oxidation of the latter is therefore possible.

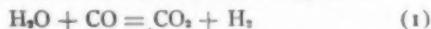
this is only possible when the dissociation pressure of the oxide of iron present has become smaller than that of $\text{CO}_2 = \text{CO} + \text{O}$.

But since this latter is dependent upon the ratio of CO to CO_2 , this will, at a relatively lower temperature, be responsible for the appearance or the non-appearance of that very unwelcome reaction. The greater this ratio is—that is to say, the less carbonic acid there is present to the carbonic oxide, or in other words, the less the carbon in the blast furnace is employed for reducing—the higher lies the temperature at which this reaction begins to occur and the more harmful is its influence.

As we have already seen, the ratio of CO to CO_2 is independent of the pressure. It forms, therefore, an excellent means of judging of the working of the blast furnace, for which purpose it has long since been employed by Gruner.

If moist air be employed, as is usually the case, the water vapor is decomposed by the incandescent fuel, and the furnace gases will be mixed with H_2 and also with CH_4 , both of which reduce ore.

The next influence will be this, that the temperature in front of the tuyeres, in consequence of the heat absorbed by the decomposition of the steam, will fall considerably, and thereby the tension of dissociation of the bodies present be lowered. Moreover, there will quickly take place an equilibrium between CO , CO_2 , H_2 and H_2O , in accordance with the equation



But, on the other hand, carbonic oxide and carbonic acid stand in equilibrium with the carbon, according to the equation



whilst the decomposition of the water takes place according to the equation



For these reactions the conditions of equilibrium are:

$$\text{For (1)} \quad \frac{[\text{CO}_2]}{[\text{CO}]} \cdot \frac{[\text{H}_2]}{[\text{H}_2\text{O}]} = K_1$$

$$\text{For (2)} \quad \frac{[\text{CO}]^2}{[\text{CO}_2]} = K_2, \text{ or } [\text{CO}] = \frac{K_2 [\text{CO}_2]}{[\text{CO}]}$$

$$\text{For (3)} \quad \frac{[\text{CO}]}{[\text{H}_2\text{O}]} \cdot \frac{[\text{H}_2]}{[\text{H}_2]} = K_3, \text{ or } [\text{CO}] = \frac{K_3 [\text{H}_2\text{O}]}{[\text{H}_2]}$$

Since the equilibrium of both CO pressures must be equal, we obtain for (1):

$$K_1 \cdot \frac{[\text{CO}_2]}{[\text{CO}]} = K_2 \cdot \frac{[\text{H}_2\text{O}]}{[\text{H}_2]}$$

From this it follows:

$$\frac{[\text{CO}_2] + [\text{CO}]}{[\text{H}_2\text{O}] + [\text{H}_2]} = \frac{K_3 [\text{CO}_2]}{K_2 [\text{H}_2\text{O}]} \text{ or}$$

$$\frac{K_1}{K_2} \cdot \frac{[\text{CO}_2] + [\text{CO}]}{[\text{CO}_2]} = \frac{[\text{H}_2\text{O}]}{[\text{H}_2\text{O}] + [\text{H}_2]}$$

Now $[\text{CO}_2] + [\text{CO}]$ corresponds to the quantity of carbon burnt, and $[\text{H}_2\text{O}] + [\text{H}_2]$ to the original water vapor present.

And since the CO_2 percentage in the gas corresponding to the higher temperature in the lower part of the blast furnace and to the hydrogen equilibrium is excessively small, the partial pressure of the water vapor must also be so, and the hydrogen can thus exercise so much the less a strong reducing influence upon the ore, as the quantity of carbon burnt is in every case much greater than the moisture of the air.

From this it follows that the presence of water vapor in the blast furnace can produce no special advantage. But, moreover, the water vapor by its decomposition uses up carbon, but

on the other hand the hydrogen present will decrease the partial pressure of CO and CO_2 and their tension of dissociation, under these conditions, at least in the lower part of the blast furnace, the presence of water vapor will ever act detrimentally. So that it would appear that the experiments made to dry the blast before its introduction into the blast furnace are well founded.

These considerations touch only a few of the points involved in blast-furnace practice, but they are sufficient to show that the new method of view serves not alone to broaden our understanding of the various chemical processes involved in blast-furnace phenomena, but also in many cases to gain new enlightenment.

Gas-Electric Power at the Mansfeld Copper Mines and Smelting Works.

Mining operations started in the famous Mansfeld district in Germany as early as 1200 and assumed considerable importance under the judicious management of the Counts of Mansfeld. The whole district soon became an important mining camp, though not in our Western sense. It is well known, for instance, that Luther's father, in Eisleben, was a miner. The operation stopped almost completely during the thirty years' war from 1618 to 1648. Later on operations were again taken up by a great number of small independent operators, but a new era began in 1852, when the independents combined to found the Mansfeld'sche Kupferschieferbauende Gewerkschaft, which was reorganized in 1876, and has made constant progress under excellent management.

The deposit of Kupferschiefer (copper schist) covers a very extended area but is only 2 or 3 feet thick. It is a bituminous schist with 1.8 to 3.7 per cent of copper in form of sulphuretted copper ores and a small proportion of silver equal to 0.53 to 0.72 per cent of copper present. The copper schist contains besides 40 per cent silica, 10.7 per cent alumina, 5.0 per cent iron oxide, 19.5 carbonate of lime, 2 carbonate of potash, and 10.3 water and bitumen.

The metallurgical treatment adopted at Mansfeld is well known. To describe it in the words of Schnabel, the ore is calcined in heaps to remove water and bitumen, and is smelted in shaft furnaces yielding coarse metal with 30 to 40 per cent copper. This is calcined in kilns and smelted in reverberatory furnaces, forming a matte with 74 to 76 per cent copper and on an average 0.45 to 0.48 per cent of silver. This is treated by Zier vogel's process, and the residue, consisting of oxide of copper and a little oxide of iron, is mixed with coal, reduced in reverberatory furnaces and refined direct. During 1906 the production was 20,000 tons of copper and 100,000 kg. of silver.

The circular shaft furnaces mentioned above have a crucible hearth and are from 24 to 29 feet 6 inches high and have six tuyeres. The diameter of the furnace at the tuyeres is from 5 feet 3 inches to 6 feet 2 inches, and at the throat 7 feet 3 inches. There are four flues at the top to take the gases off into the gas main, where it was formerly used for raising steam and in several of the furnaces for heating the blast.

Until lately all the machinery scattered over an area of more than 25 square miles—which is the present extension of the mines—was driven by steam engines with a large number of boilers distributed over this area. The advantages of supplying electric power over this area were so manifest that the question of using the furnace gases in gas engines for the generation of electric power were carefully studied, and after preliminary investigations and experiments had been successful, the complete electrification of the mines and the smelting works was decided upon. In three recent issues of London *Electrical Engineering* we find a very interesting article by Mr. H. R. SPEYER on the present electric equipment of these mining and smelting works, and from this article the following summary has been prepared.

The three principal copper smelting works in the order of their importance are the Krughütte, the Kochhütte and the Eckardthütte, and the underlying idea of the scheme is to erect generating stations at these three places and connect the three stations by means of underground cables by a ring trunk main, so that, in the event of a breakdown occurring in any one, the remaining two will still send energy over the whole system. The total length of the ring is 13.87 km. (over 8 miles). This scheme was, however, extended by erecting a fourth station at the Kupferschieferhütte, which is steam driven, because the blast-furnace gas at this works is too poor in calorific value. The gas is used, however, for firing one of the two batteries of boilers.

Underground cables were chosen for the ring line because the routes pass through a great number of villages and along highways, and in order to avoid disturbances due to the very frequent severe local thunderstorms.

The following table gives the percentage of carbon monoxide in the blast furnace gases of the three plants, the number of cubic meters of gas per hour and the maximum and minimum horsepower available in the three gas-driven stations:

	Cubic Meters % CO.	Maxi'm. Per Hour.	Mini'm. H.P.
Krughütte	21.65	21,000	4,500
Kochhütte	18.6	14,000	2,600
Eckardthütte ...	17.65	9,000	1,600
			700

The horsepower available varies, because the furnaces are cut out from the main delivery gas pipe during feeding, tapping and cleaning, and it sometimes happens, in spite of efforts to the contrary, that these operations are carried out on more than one furnace simultaneously. Further, the calorific value of the gas may at times decrease by as much as 10 per cent.

The gas as it leaves the furnace is absolutely unsuitable for direct use in gas engines owing to the presence of a large quantity of finely divided dust. It is, therefore, cleaned in Theisen centrifugal contraflow washers. Before entering the washers the gas contains 17 grams of dust per cubic meter, namely, 0.83 per cent copper, 0.01 silver, 33.12 lead, 0.75 arsenic, 22.5 insoluble zinc, 2.5 soluble zinc, 2.84 sulphuric acid, 13.97 sulphur, 6.14 silicon and 2.40 carbon. Traces of Cl_2NH_2 , cadmium and manganese are also present.

After cleaning only 0.003 grams of dust are contained per cubic meter of gas. This dust is of similar composition except that the proportion of lead is increased to 41 per cent on account of the disappearance of the more soluble ingredients. The lead is present in the form of PbO_2 and the zinc as ZnS .

At present only the gas plant at Krughütte and the steam plant at Kupferschieferhütte are complete. The blast furnaces at the Krughütte are all connected to two parallel gas trunks, having an internal diameter of 1,600 mm. and 1,000 mm. respectively. They are so arranged that each and all can exhaust into either pipe while the other is being cleaned. These two gas trunks serve to lead the furnace gases to the purifier house, where three Theisen washers are installed. Their construction is shown in Fig. 1, which shows the general arrangement of one of these washers.

It consists of a conical metal casing (A) lined with wire gauze, within which a drum (d) fitted with spiral blades (e) revolves at a peripheral speed of 3,000 meters per minute. The blades of this drum are so formed at their ends (f) as to draw in the gas at one end of the casing (C) and expel it at the other (c). Water is admitted through the opening (g) at the side of the casing, and is finally sprayed by the blades, being caused by their spiral form to flow in the opposite direction to the motion of the gas. The water leaves the cleaner by the water seal (h), and is conducted to a settling tank. It may be mentioned that the deposit in the settling tanks contains at least 25 per cent of lead, which is afterwards recovered. The gas on leaving (c) is dried by being passed through a Theisen vapor separator.

The action of the apparatus is continuous, and as the bearings are fitted with ring lubrication, practically no attention is required. Before reaching the actual washer the gas is passed through a preliminary saturator, where some of the heavier dust is separated. The three washers at the Krughütte are together capable of dealing with over 30,000 cubic feet of gas per minute, and use in all approximately 200 gallons of water per minute. From the cleaning plant the gas passes into a gas reservoir having a capacity of 500 cubic meters.

The gas is supplied to two 1,300-hp. Oechelhäuser gas engines coupled to 3,000-volt three-phase generators, each of 1,080 kw.

The cables are designed partly for 3,000-volt and partly for 10,000-volt transmission. By means of transformers the lines of different voltage are connected together so that the whole transmission line forms one solitary unit. Almost along the whole ring the cables have been laid in duplicate to provide against the dangers of a breakdown.

The three-phase system, besides its other advantages for transmission, was specially chosen on account of the great reliability of working three-phase induction motors, with which there is no difficulty of starting (as with single-phase induction motors), and which on account of lack of any commutator are much more fool-proof and require much less attendance than

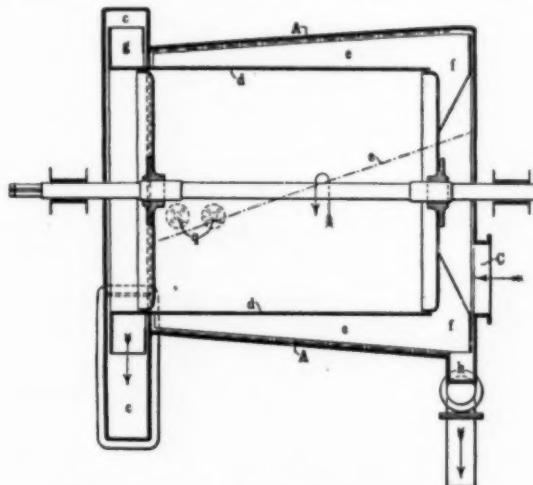


FIG. 1.—SECTION OF THEISEN GAS WASHER.

direct-current motors. In Krughütte the electric power is used for various purposes in the workshops and also for driving the rotary blowers which supply the forced draft to the furnaces. These induction-motor blower sets are kept running continuously day and night. The blowers are of extremely simple construction, and are entirely without valves. As the revolving parts do not come into actual contact the efficiency is comparatively high, being approximately 75 per cent. Each blower is designed for an output of 250 cubic meters of free air per minute at a pressure of 100 mm. of mercury. They run at a speed of 250 r. p. m., and each is belt-driven by a 125-hp. motor, running at 750 r. p. m. on the 3,000-volt, 50-cycle, three-phase circuit.

Smaller applications of three-phase induction motors at the same smelting works are for driving two centrifugal pumps, each with an output of 75 liters per minute, for circulating the cooling water of the furnaces, and for operating the molding machines in which the ore fines and dust are compressed into brick to be fed into the furnaces. The feeding mechanism of the furnaces is driven through chain transmission by three-phase motors. The gear for each furnace is capable of dealing with 3,000 550-kg. wagons per 24 hours.

The Krughütte smelting works are connected with the Hermann pit by an aerial steel rope 7 km. in length (over 4 miles), which is driven from a 10-hp. motor. A second motor

has been erected as reserve. The energy cost of transportation per kilometer-ton during the months of January to April, 1907, varied between 0.07 and 0.056 cents, while the total transportation cost varied between 5 and 4 cents.

The most interesting application of electric power is the equipment of the Hermann pit, wherein an electric main-shaft-winding plant has been installed (besides the use of electric power for other purposes, as ventilating, pumping, lighting, etc.). The winding plant is on the system which is known in Europe as the Siemens-Illner system.¹

The whole system of the connections is clearly shown in Fig. 2. The speed of the winding motor corresponds definitely to the position of the control lever, and an accelerating or braking effect is produced according as the lever is moved from a position corresponding to a higher or lower speed, independently of the amount of load on the machine, or whether the cage is

actuated by relays is used, which cuts resistances in and out of the rotor circuit as required.

The general particulars of the winding plant at the Hermann pit are as follows: Output, 760 tons per 8-hour shift; depth, 366 yards, to be extended later to 633 yards; number of trucks per cage, 4; effective load, 4,930 pounds; maximum rope speed, 1,180 feet per minute, to be increased later to 2,340 feet per minute; A. Koepe pulley, 16 feet 6 inches diameter, is used with a rope 1.5 inches in diameter. The fly-wheel set is driven by a three-phase, 3,000-volt induction motor, rated at 320/292 hp. and running at a maximum speed of 493 r. p. m. The continuous-current generator is wound for a maximum voltage of 400 volts and an output of 1,440 amps. The winding motor can work up to 665 hp. at 400 volts, at a speed of 38.5 r. p. m. The total energy stored in the fly-wheel is 140,000 kilogram-meters, which is more than enough to complete the wind

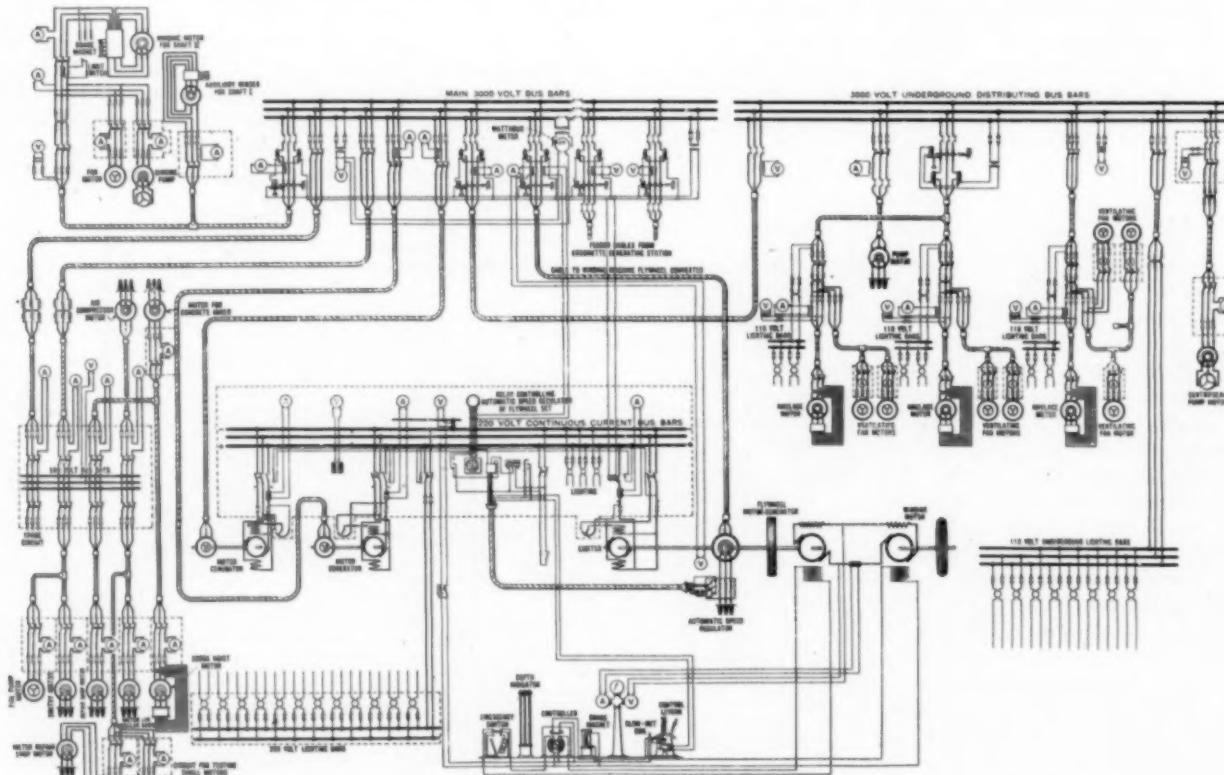


FIG. 2.—DIAGRAM OF CONNECTIONS, HERMANN PIT, MANSFIELD COPPER MINES.

ascending or descending. The control apparatus itself is only required to carry the relatively small excitation current of the generator, which is not more than 2 to 3 per cent of its output.

The speed of the motor generator varies from about 12 per cent to 15 per cent, as the rotating masses absorb or give out power; and to enable the three-phase motor to absorb practically constant current from the line, an automatic regulator

should the current supply fail. The set has been at work since April, 1905.

An important item of the equipment is the depth indicator, with which is combined a safety gear. The principle of the safety apparatus consists in the use of a cam-wheel, the movement of which is synchronous with that of the indicator, and which controls automatically the position of the control lever, and consequently the speed of the cage during the whole time of the wind. This cam is composed of two discs mounted upon the same shaft, each corresponding to one direction of working. Their speed of rotation is such that they make one complete revolution per wind. The control lever is connected to rollers which press against the cams when the driver moves the lever.

The variations in the profile of the cams limit the distance through which the driver can move his lever, according to the position of the cage in the shaft. At the beginning of the wind the driver moves his lever in the required direction, but without being able to pass the position fixed by the corresponding cam. The winder starts and attains the speed corresponding to this position, the cam wheel rotates simultaneously and allows of the lever being further advanced, so that the speed is increased,

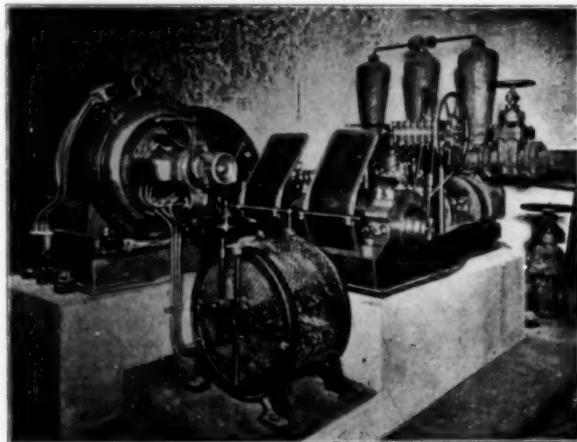
¹This system is in principal identical with the Ward-Leonard system, and differs only in details from the latter. Since it seems to acquire considerable importance also in this country its fundamental principles may be briefly explained. Three-phase induction motors would be unsuitable as winding motors and direct-current motors must necessarily be used. It is, therefore, necessary to transform the three-phase currents into direct current. This is done by means of a motor generator set, consisting of a three-phase induction motor and a direct-current generator. The direct-current generator supplies direct current to the winding motor. On account of the considerable variations of load which would react injuriously on the transmission and distributing system, the motor-generator set is coupled with a heavy fly-wheel, which takes up the variations of load. The control of the winding motor is accomplished by varying the excitation of the direct-current generator which forms part of the motor-generator fly-wheel set. In this country the same system in principle is used by both the General Electric Co. and the Westinghouse Co. The General Electric Co. have installed, for instance, recently this system for the Kendall Gold Mining Co., Kendall, Mont., as described in an article by H. R. Clark in a recent issue of the *General Electric Review*. While in a recent article of the *Electric Journal* (of the Westinghouse Co.), W. E. Reed describes the application of the same system for reversing steel mills.—Editor.

and so on until the maximum is reached. The form of the cam thus determines the rate of acceleration.

The driver is always able to draw back his lever for reducing the speed. If he forgets to do this at the right time towards the end of the wind, the lever is returned automatically by the cam, and the speed of the winder is retarded at a prescribed rate. The cam is of such a form that at the part corresponding to the end of the wind it returns the control lever automatically so far back that the speed falls to quite a small value, but from this instant the profile is concentric with the axis of the disc, so that the driver is able to use this slow speed in the neighborhood of the pit bank for the purpose of carrying out the necessary operations connected with the landing and starting of the cage.

The driver retains this power of carrying out the necessary operation at low speed up to the moment when the cage passes the bank. At this instant the profile of the cam makes an abrupt change, and rapidly returns the control lever to the off position. At the same instant a stop works upon an unlocking gear at the end of the run, which immediately puts on the safety brake, and the winding engine, which has already been slowed down, is brought entirely to rest.

It is thus seen that the safety apparatus compels the driver at each wind to adhere, whatever the load, to the rate of



ELECTRICALLY-DRIVEN PUMP IN ZIRKEL PIT.

working which has been prescribed. It in no way interferes with the driver, so long as he operates the levers correctly, but in every case resists an attempt to move them wrongly. The absolute security ensured by this apparatus has been recognized by the (Prussian) inspection commission for winding men in the mining district of Dortmund, who have given permission for the speed of winding to be raised from 6 meters per second, the maximum hitherto allowed, to 10 meters per second when winding men.

It is interesting to note that the actual working results have shown considerably increased economy, especially if the results at the electrically-operated Hermann pit are compared with the costs of the steam winding at the Niewand and Zirkel pits under similar circumstances. The steam power cost per ton-kilometer in the latter two varied between 11 and 9 cents per ton-kilometer from January to June, 1907, while the cost of electric power at the Hermann pit per ton-kilometer was only 4 cents. This cost, however, is in both cases only for the value of the actual energy consumed and does not in either case cover incidental expenses incurred during the six months. The results obtained with the electric winding plant in the Hermann pit have been so satisfactory that the electrification of the main winding gear in those other pits, which still have a number of years to run, is to be proceeded with at once.

At the Oberhütte motor a generator set is installed to supply direct current to an electrolytic refinery.

At the Hohenhthal pit the underground roadways, which were formerly driven by compressed air supplied from a steam-driven air compressor, have been electrified with a very considerable reduction of cost of operation, the cost per horsepower being only one-fourth of the former method. The electrification has been carried out by using the fly-wheel of the air engine as the belt-driven pulley of the three-phase 3,000-volt 100-hp. motor. In all other respects the engine remains unchanged, with the result that the roadways can still be driven with the air engine should the necessity arise. The underground ventilators, the boring machines, as well as the workshops at the surface, are also electrically driven.

Since an inrush of water was expected in this pit a complete electric pumping plant has been erected, but, unfortunately, the inrush of water came at another place than had been expected. Nevertheless, should the water rise further it will be possible to employ this pumping plant.

The Zirkel pit, which lies outside of the actual cable ring, is supplied with 10,000 volts three-phase currents, which are transformed down to 3,000 volts at the pit mouth. At this pressure the current is taken down the shaft of the pit, a distance of 2,200 feet, by means of a three-core cable. At the fifth, and at present last seam, there is another transformer which further reduces the pressure of one circuit to 500 volts. At this voltage the motors are operated for working underground roadways.

The output of the largest ventilating fan in the Zirkel pit which is used for circulating air in the fourth seam, is 4,000 cubic meters per minute when working against a pressure of 100 mm. of water. The diameter of the blades is 10 feet. This fan is belt-driven by a 3,000-volt 185-hp. induction motor. In the same machine room is erected a 30-hp. 500-volt three-phase induction motor for driving a centrifugal pump used for pumping the water up to the storage tanks placed over bank at the surface. This pump is shown in Fig. 3. There are also three small ventilators driven by 30-hp. three-phase motors.

As will be seen from the above description the electrification of the mining and smelting works has not yet been completed, but in view of the excellent results so far obtained the further equipment of the works with electric power is going on.

The Duluth Power Development and Electro-chemistry.

We have repeatedly referred to the important development of power by the Great Northern Power Co. at Duluth. Since September the plant is in operation. While the present station has been designed for eight generating units of 10,000 hp. each, only three are at present working. But even after all eight units will have been installed, it will be possible, by new water-power developments, to increase the capacity still further to a total of 150,000 or 200,000 hp. The power plant is an excellent example of modern engineering practice. The entire electrical equipment has been supplied by the General Electric Co.

Twenty-two thousand electric horsepower have already been contracted for, partly for lighting and traction in Duluth and the neighborhood, but to a large extent for power purposes. Thus the great coal docks at the head of Lake Superior are to be electrically equipped, and many of the large manufacturing concerns in the neighborhood are expected to become customers of the power company. The United States Steel Corporation will be among them, since the power produced from by-product coke-oven gases, with the aid of gas engines, will not be enough to fill all requirements.

The American Carbolite Co., which makes calcium carbide under the patents of Mr. H. L. Hartenstein (our Vol. IV., pp. 237, 289, 369; Vol. V., p. 102), also gets electric power from the company. They are now operating nine electric furnaces, but will increase the number of these furnaces in the near future to twenty-one, each furnace requiring about 250 hp.

A Graphical Representation of the Solidification of Eutectic Alloys.

BY ALBERT SAUVEUR,
Professor of Metallurgy in Harvard University.

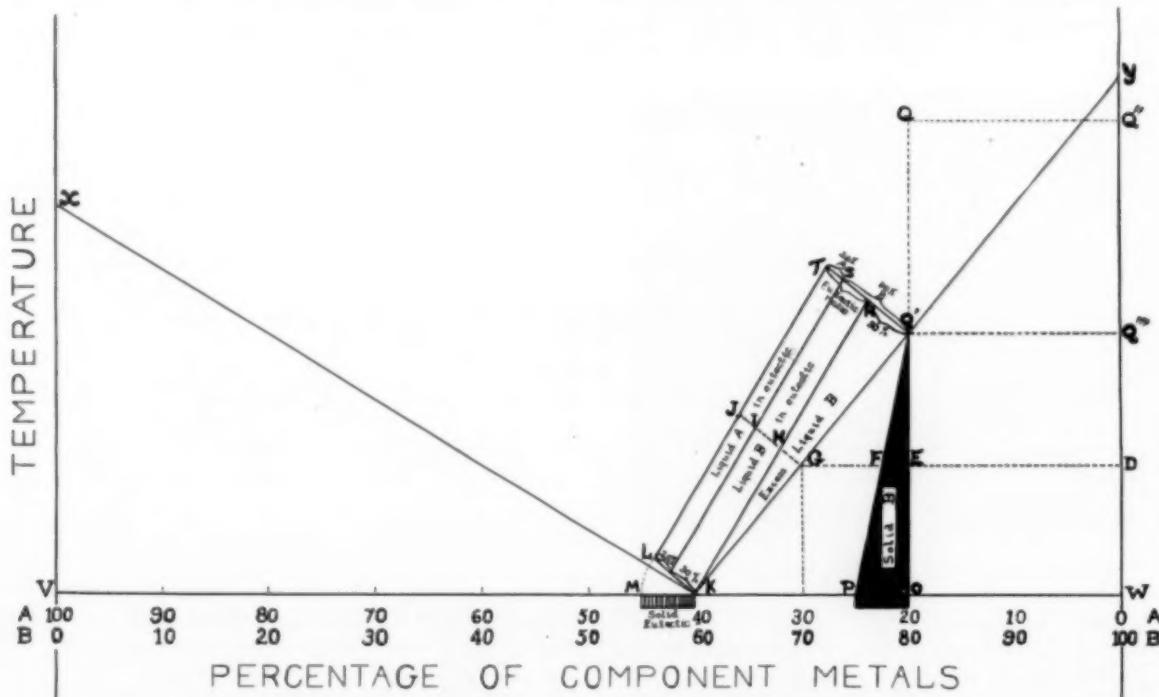
The accompanying diagram has been found of much assistance in explaining in the lecture room the mechanism of the solidification of a certain group of metallic alloys and it is reproduced here in the hope that it may likewise be of value to others.

An attempt is here made to illustrate graphically the solidification of an alloy composed, after complete solidification, of a certain amount of "excess metal" and of "eutectic." Its interpretation should be readily understood.

The curves XK, YX and VW represent the fusibility curves of alloys composed of the two metals A and B. The branch XK indicates the beginning of the solidification of excess metal A, the branch YK the beginning of the solidification of excess metal B and the branch VW the solidification, at a constant temperature, of the eutectic, which in the series of alloys

ture Q' and ending at the eutectic temperature W, when the alloy contains PO or fifty per cent of solid B. The figure KLTQ' illustrates the changes which occur in the liquid portion of the alloy during the solidification period. In this figure the parallelogram KLTR represents the portion which remains liquid until the freezing of the eutectic takes place; we may call it the liquid eutectic. It is, of course, made up of 20 parts of A, and 20 parts of B. The triangle KRQ' represents the excess liquid B which must solidify before the eutectic temperature is reached. The alloy after complete solidification is made up of PO (fifty per cent) excess B and LK=MK (fifty per cent) eutectic.

To further explain the use of the diagram, let us consider the condition of the alloy at the temperature D, or about half way between the beginning and the end of its solidification. At that temperature it contains FE (about twenty-five per cent) of solid metal B while JG (about seventy-five per cent) still remains liquid. In percentages the liquid portion now contains about thirty per cent of A and seventy per cent of B; it is approaching the eutectic ratio which calls for 40 A and 60 B. HG represents the amount of excess liquid B still to



selected contain 40 parts of metal A and 60 parts of metal B.

Let us consider the case of an alloy of this series containing twenty per cent of A and eighty per cent of B, and represented in this diagram, when above its melting point, by the point Q. As this alloy cools from Q to Q', that is, from temperature Q'' to Q''' , it remains liquid, solidification beginning immediately upon lowering the temperature below Q''' . The 20 parts of metal A contained in this alloy will unite with 30 parts of metal B (the eutectic ratio being 40 to 60 or 2 to 3) to form a eutectic, and will leave, therefore, 50 parts of "excess" B to solidify as the metal cools from Q' to Q.

To show this graphically the composition of the alloy above its melting point is represented in the diagram by the line TQ', of which the portion TS represents the twenty per cent of metal A wholly absorbed by the eutectic, the portion SR the thirty per cent of metal B to be found finally in the eutectic, and the portion RQ' the fifty per cent of excess metal B which must solidify before the solidification point of the eutectic is reached. The solid black triangle Q'PO represents the gradual solidification of the excess metal B, beginning at the tempera-

solidify before the eutectic ratio is reached, and which will solidify as the alloy cools from E to O. JH represents the portion of the alloy which will remain liquid until the eutectic temperature is reached, JI representing the amount of metal A and IH the amount of metal B in the eutectic.

By this method the sliding of the composition of the liquid portion of the solidifying alloy along the branch YK so often alluded to is clearly illustrated.

Zinc in the United States.—From Mr. Boutwell's Geological Survey report on zinc it appears that this country, while second among zinc producers, is first among the consumers. The production of zinc in the United States in 1906 was 224,770, the consumption 221,781 short tons, the corresponding figures for the world being 775,871 and 731,043. "In the long run, continued increase in the use of zinc promises to return the present great increase in production, and as consumption thus presses upon production again it is believed that prices will gradually rise and render the zinc industry an increasingly profitable field for enterprise."

Electrochemical Analysis with Rotating Anodes in the Industrial Laboratory.

BY ANDREW M. FAIRLIE AND ALBERT J. BONE.

I.

The advantages of a rotating anode in electrochemical analysis were first brought into prominence by Exner¹ in 1903, although Smith, quoting Wimmenauer, had previously described a revolving anode for use in the determination of bismuth.² Since the appearance of Exner's paper, investigation into the value of the mechanical appliance which he advocated has been zealously pursued by others; and, indeed, this study, fostered by Prof. Smith, has become a specialty in the department of chemistry at the University of Pennsylvania.

The work at the university, naturally, has been purely scientific in character, and it remained for the technical chemist to apply practically the principle which in the laboratory of pure science gave such promising results.

In 1905, Heath³ made scant reference to a rotating anode used by him in the laboratory of a large copper smelting company. The following year Larison⁴ described an apparatus for agitating copper assays by means of independent glass stirrers; the electrodes, however, remaining stationary.

The present paper describes a system of rotating anodes evolved in the laboratory of the Tennessee Copper Co. for the estimation of copper in slags and other products of a copper mining and smelting company, and designed to execute as many as eight determinations simultaneously. A discussion of methods of analysis used in connection with this apparatus will appear in a later issue of this journal.

THE APPARATUS.

The mechanism for rotating the anodes consists primarily of eight anode holders, or spindles, of steel (Fig. 1), revolving in as many brass supports (Fig. 4) securely bolted to the

¹ *Jour. Amer. Chem. Soc.*, XXV, p. 896.

² Edgar F. Smith, *Electro-Chemical Analysis*, 3d ed., p. 76.

³ *Jour. Amer. Chem. Soc.*, XXVII, p. 317.

⁴ *Engineering and Mining Journal*, Dec. 22, 1906, p. 1,168.

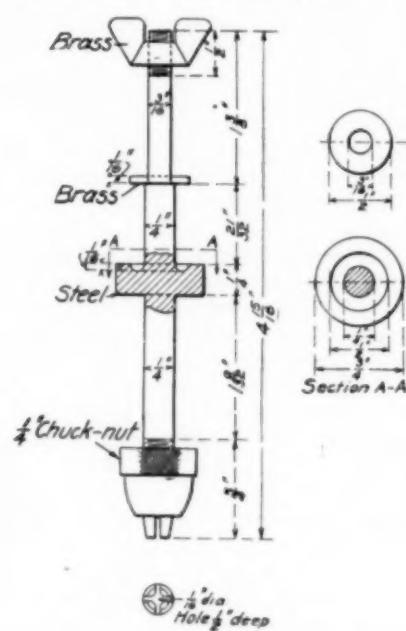


FIG. 1.—ANODE HOLDERS.

switchboard in a horizontal row, and 4½ inches apart. Each spindle carries at the top of a double-grooved wooden pulley 2 inches in diameter, driven by a round belt which connects all the pulleys with one another and with the motor. The latter is a 1/6-hp. vertical machine, 220 volts, enclosed type, speed variable by means of a rheostat between 900 and 1,200 r. p. m., and carries at the bottom a brass pulley 1 inch in diameter for the driving belt.

The cathode holders are ordinary binding posts, screwed into

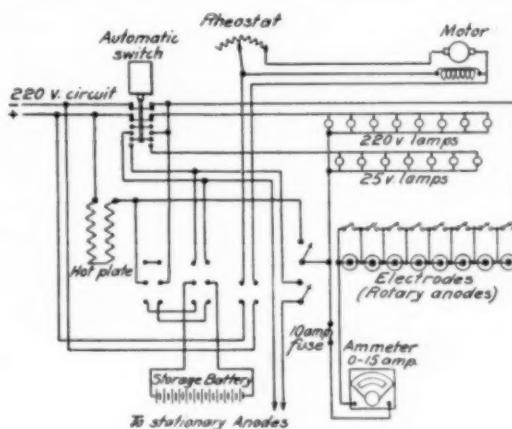


FIG. 2.—ELECTRICAL CONNECTIONS.

the edge of a board 3 feet 5½ inches long and 4½ inches wide, nailed to the switchboard edgewise and supported by two wooden brackets, as shown in the photograph (Fig. 3).

In shape the electrodes used with this apparatus differ from those suggested by Heath. The cathode (Fig. 6) is a perforated platinum cylinder, without top or bottom, with stem attached, and is of the dimensions shown in the figure. The perforations, sixty in number, and each 4 mm. in diameter, are distributed around the body of the cathode in four rows of fifteen holes each. The total area of cathode surface immersed

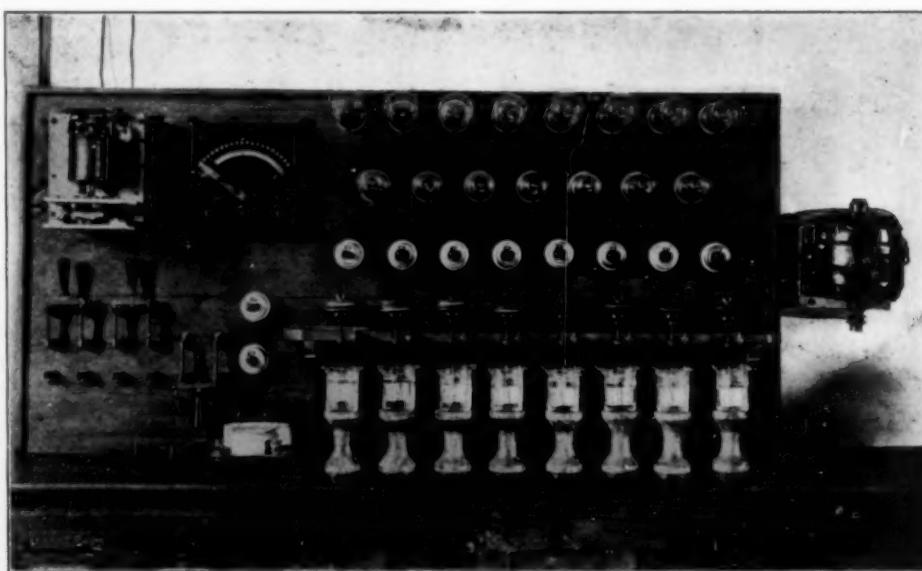


FIG. 3.—PHOTOGRAPH OF ARRANGEMENT.

in a solution is 100 sq. cm. (nearly). The weight of a cathode is about 16 grams.

The anode is a piece of hard platinum wire, 1.4 mm. thick and 108 mm. long, terminating at the lower end in a platinum propeller wheel, 31 mm. in diameter (Fig. 5). The wheel has

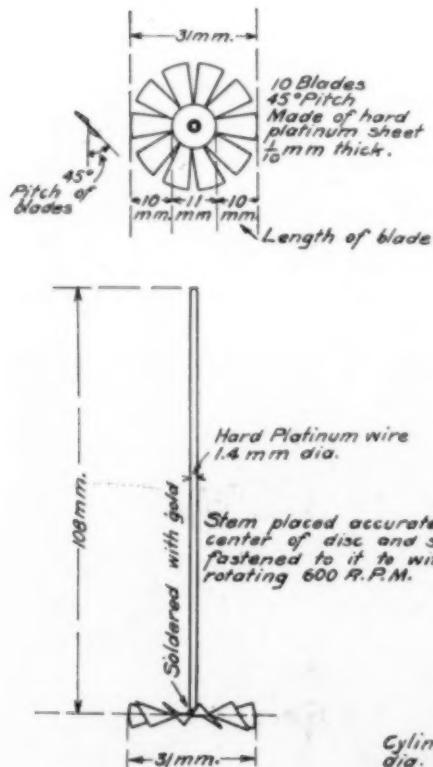
ten blades, set at a 45° pitch, and is soldered to the stem with gold. The anode complete weighs about 6 grams.

In using the electrodes the anode is securely fastened in the anode holder by means of the chuck nut at the lower end of it, and the cathode is adjusted in its binding post in such a way that the propeller will revolve in the center of the cylinder.

Electrically, the anode holders and the binding posts for the cathodes are connected in series. Over each pair of electrodes there is a switch (see Fig. 3), by closing which it is possible to remove a completed determination without interrupting the current in any of the others.

The current for the analytical work is derived from the 220-volt lighting circuit. At the time the rotating apparatus was installed the laboratory happened to be using, for heating purposes, an electric hot plate, provided with two switches, for heat regulation. It was found that with one of these switches closed a current of 3 amps. could be obtained, or with the other, 5 amps., or with both closed, 8 amps. Since 3 and 5 amps. are suitable current strengths for electrolysis with rotating anodes, the hot plate was made to serve a second useful

ANODE
Made of Platinum
Weight approx. 6 grams



FIGS. 5 AND 6.—ANODE AND CATHODE.

purpose, and has been adopted as a rheostat for the current going to the electrolytic apparatus.

To open one of the switches of the hot plate, however, means less heat available from it, and at times when the full heat is required it is inconvenient to open a switch. In order to provide

for a conflict, as well as to furnish a means of increasing and decreasing the current by degrees, eight lamp sockets (the top row in Fig. 3) are connected in parallel with one another and in parallel with the hot plate. With one 16-c.p. and seven

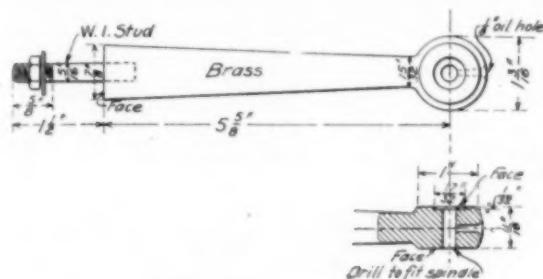


FIG. 4.—BRASS SUPPORTS.

32-c.p. lamps it is possible to obtain as much as $3\frac{3}{4}$ amps. without the aid of the hot plate (a cut-off switch for which has been provided). By means of lamps and hot plate combined one can regulate the current by steps of $\frac{1}{4}$ amp. from 0.25 amp. to the highest current that is of practical use for this work.

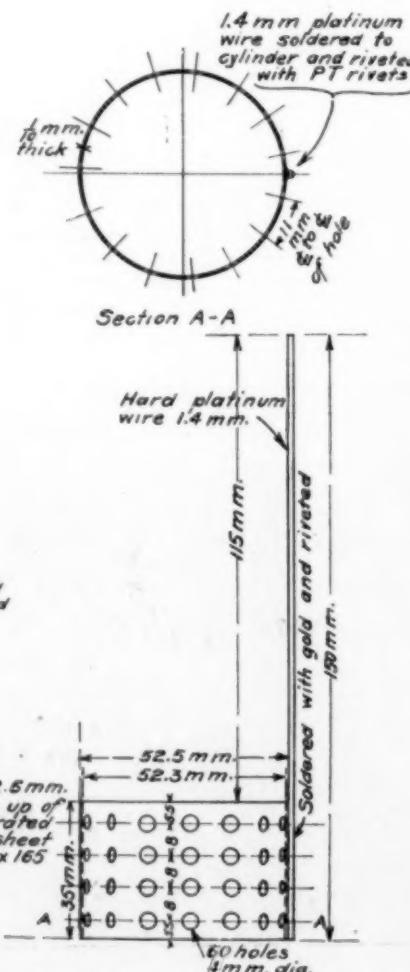
It is well known that any interruption of the electric current during electrochemical analysis casts doubt upon the accuracy of the work and always causes delay and annoyance. To shield the work on this apparatus from the whims of circuit breakers—mechanical and human—an automatic switch has been installed, which, on the failure of the lighting circuit, immediately drops and connects a battery of storage cells with the electrolytic work.

The current from the storage battery is regulated by means of the lower row of lamps (Fig. 3). Upon the return of the 220-volt current the switch rises, automatically cutting out the storage cells and connecting the electrodes to the lighting circuit as before. The storage cells, while able to discharge at a rate of 3, or even 5 amps. for a short time, have not capacity enough to permit continued use at such a rate.

It may be remarked in passing that a third use has been found for the electric hot plate mentioned above. When not in use as a rheostat for the current going to the electrolytic apparatus, it can be used as a rheostat in charging the storage battery at an 8-amp. rate without interfering with its usefulness as a source of heat.

This somewhat complicated apparatus has been developed step by step from a modest beginning—a single jeweler's buffing spindle geared horizontally to a very large wheel, patiently turned by a very small boy. Various hands and minds have been concerned in the evolution, and thanks are

CATHODE
Made of Platinum
Weight approx. 17 grams.



due especially to W. K. Freudenberg, electrician, who devised the automatic switch and installed the intricate system of wiring for the switchboard. A second article will follow.

COPPERHILL, TENN.

Melting Iron in the Foundry Cupola.

BY PROF. H. McCORMACK.

The work described in the following pages was undertaken in the foundry of Armour Institute of Technology with the view of securing some data on cupola practice which would be of economic value.

For this experiment the melting was conducted, as has been customary, in this foundry.

The cupola is one made by the Whiting Foundry Equipment Company, size inner diameter, 0.565 m.; height of charge, 1.0 meter.

The blast is supplied by a motor-driven fan blower.

The charge for this heat consisted of 725.76 kilos of pig iron, 147.2 kilos of coke, and 45.36 kilos of limestone flux. It was charged as follows:

	Kilograms.
Bed charge of coke.....	99.8
Pig iron.....	272.2
Limestone.....	22.7
Coke.....	22.7
Pig iron.....	226.8
Coke.....	22.7
Limestone.....	22.7
Pig iron.....	226.8

The analysis of the—

	Graph.	Comb.	Sul-	Phos-	Man-	Sili-
	Carbon.	C.	phur.	phorus.	ganese.	con.
Pig iron.....	3.62	0.585	0.08	0.376	0.615	2.23
Cast iron produced.	2.63	0.86	0.08	0.535	0.464	2.11

The coke analyzed: Ash, 13.08; sulphur, 2.15; phosphorus, 0.212.

Blast Data.—The blast pressure was 1.2 inches of water = .071 oz. = 2.40 gm. The blast velocity was taken by means of a Pitot tube attached to a differential gauge, and was found to be 2 g. \times 81.7 or 72.5 ft. per second = 22.09 meter per second.

Area of blast pipe = 0.02136 sq. meters.

Volumes of air delivered = 22.09 \times 0.02136 = 0.4718 cu. meters per second.

Volume corrected for pressure = .47295 cu. meters.

Volume of air delivered per minute = 60 \times 0.47295 = 28.377 cu. meters.

The temperatures were taken of the escaping gases with a Whipple temperature indicator, and of the metal and slag with a Féry radiation pyrometer. Temperature of the room 23° C. The blast was turned on at 2:56 and the temperature taken then and at subsequent intervals as follows:

Time	2:56	2:59	3:00	3:1:30	3:2:30	3:3:30	3:4
Temperature, C...	105°	250°	282°	372°	465°	480°	545°
Time	3:5	3:6	3:10	3:23	3:27	3:30	3:35

Temperature, C... 665° 760° 851° 945° 1090° 1260° 1275°

The blast was shut off and the bottom dropped at 3:35.

The amount of slag was 58.9 kilograms.

Amount of coke in bottom drop, 2.2 kilos.

The slag was very dark in color, showing an excess of iron.

The cast iron produced was of good quality, poured and machined well.

It gave tension tests of 33,100 pounds per square inch, and 31,900 pounds per square inch.

Transverse tests of 1,460.00 pounds per square inch and 1,461.60 pounds per square inch.

The calorific value of the coke was determined in the Parr calorimeter and found to be 3,218.5 calories.

Heat lost in the escaping gases:

The melting lasted 39 minutes.

28.377 cu. meters of air were supplied per minute.

$39 \times 34.02 = 1,104.5$ cu. meters of air supplied during the melting.

1 cu. meter of dry air weighs 1.2923 kgm.

$28.377 \times 1.2923 = 36.67$ kilo of air per minute.

Specific heat of air = 0.2374.

$0.2374 \times 36.67 = 8.7055$ calories per minute to raise the air 1° C.

Average temperature 1st 6 minutes, 444° C.

$8.7055 \times 6 \times 444 = 23,191.4$

Average temp. 6th to 12th minute, 615° C.

$8.7055 \times 6 \times 615 = 32,123.3$

Average temp. 12th to 24th minute, 916° C.

$8.7055 \times 12 \times 916 = 95,690.8$

Average temp. 24th to 33d minute, 1,035° C.

$8.7055 \times 9 \times 1,035 = 81,091.7$

Average temp. 33d to 39th minute, 1,200° C.

$8.7055 \times 6 \times 1,200 = 62,679.6$

Total to heat air for 39 minutes..... 295,576.8

Calories to melt iron and raise its temperature:

Weight of iron..... 725.76 kg.

Specific heat of iron..... 9.1124

Latent heat of fusion..... 33.0

Melting point (LeChatelier)..... 1,220° C.

Temperature of iron coming from the cupola, as taken by pyrometer, 1,275° C.

$725.76 \times .1124 \times 1,220 = 99,523.47$ calories to raise to melting point.

$725.76 \times 33 = 23,950$ to melt.

$725.76 \times .1124 \times .55 = 448.66$ to raise melted iron to 1,275° C.

Total calories applied to iron = 123,922.1.

Calories used in slag formation:

To change CaCO₃ to CaO 167.68 cal. per kilo.

$45.36 \times 167.68 = 7,605.96$ calories.

Amount of slag, 35.5 kilograms.

550 calories are required per kilogram for slag fusion (Richards).

$35.5 \times 550 = 19,525$ calories.

$19,525 + 7,605.96 = 27,130.96$ calories applied to slag.

Calories to heat fire brick of cupola:

Inner diameter, 0.565 m.

Height of fusion zone, 1.00 m.

Brick have thickness of 0.11 meter.

$.565 \times 1.0 \times .11 = .06215$ cubic meters of fire brick to be heated by coke.

Specific gravity of brick = 2.2.

$2.2 \times .06215 \times 1,000 = 136.73$ kilos of fire brick.

Specific heat of fire brick, 0.26.

Assume 800° C. as the average temperature of the fire brick, then:

$136.73 \times 0.26 \times 800 = 28,440$ calories to heat fire brick.

Summary:

	Per Cent.
--	-----------

Calories to heat air..... 295,576.8 57.3

" " heat and melt iron... 123,922.1 24.1

" " form and heat slag... 27,130.9 5.3

" " heat cupola brick.... 28,440.0 5.5

" for radiation (by difference) 39,990.5 7.8

Total 515,060.3 100.0

Calories from the coke:

Assume to have 2.2 ko. in bottom drop leaves 145.0 kilo consumed in cupola.

$$3,218.5 \times 145 = 466,682 \text{ calories.}$$

Calories from oxidation of carbon and silicon in the pig iron:

Carbon:

	Per Cent.
Loss of carbon	
Total carbon in charged iron	4.205
Total carbon in cast iron	3.490
Carbon oxidized	0.715
$.715 \times 725.76$	
$\frac{100}{100} = 5.189$ kilograms of carbon.	

$$\text{Calories, carbon oxidized to CO}_2 = 8,080.$$

$$5.189 \times 8,080 = 41,927.1 \text{ calories.}$$

Silicon:

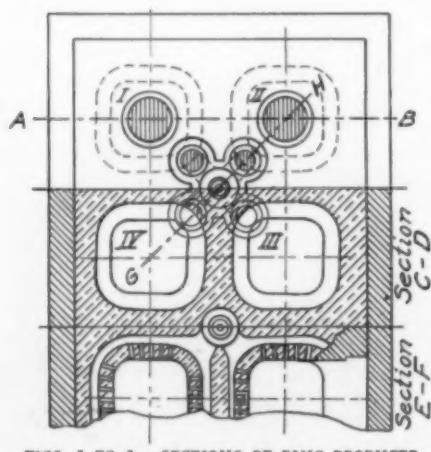
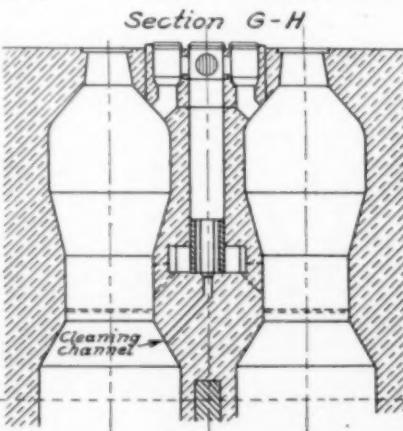
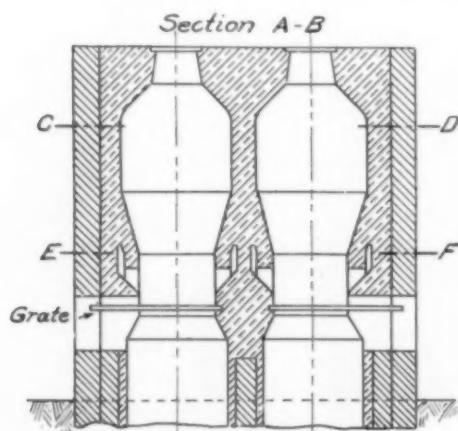
	Per Cent.
Loss of silicon—	
Silicon in charged iron	2.23
Silicon in cast iron	2.11
Silicon oxidized	0.12
$.12 \times 725.76$	
$\frac{100}{100} = .871$ kilograms silicon.	

$$\text{Calories, silicon to silicon dioxide, } 7,407.$$

$$7,407 \times .871 = 6,451.2 \text{ calories.}$$

Summary of calories developed:

From coke	466,682.
" carbon of iron	41,927.1
" silicon of iron	6,451.2
Total	515,060.3



FIGS. 1 TO 3.—SECTIONS OF RING PRODUCER.

The slag from this heat was unsatisfactory, being dark and viscid. Calculation also shows a deficiency of calcium oxide. The amount of heat consumed in heating the air seems excessive. In view of these facts, it was decided to run the next heats with less volume of air and with a higher ratio of flux. The gases escaped from the cupola at an excessively high temperature, the greater part of the time being above 1,000° C. This could be materially lowered if more metal was to be melted, so that the escaping gases could be utilized in heating the charge, and shows that there is fuel economy in melting over a long period in a small cupola rather than for a short time in a large one, as the principal fuel loss is in the heat carried away in the escaping gases. Further experiments are being conducted along these lines. I am indebted to Mr. Agle, shop superintendent, and to Mr. Howell, foundry foreman, for the very great assistance they have rendered in carrying out these tests.

Laboratory of Armour Institute of Technology, Chicago.

The Jahns System of Transforming Solid Fuel into Gas.

BY OSKAR NAGEL, PH. D.

There can be no doubt that as soon as the common fuel used at present for generating steam in our industrial plants can be transformed by a simple process into gas, which can be used for both fuel and power purposes, a wide field of application will be opened for producer gas.

The Jahns ring producer is accomplishing these results. A number of these producers are now in operation and giving the best of satisfaction at several German and Belgian coal mines. In these producers the lowest grade of bituminous coal, sometimes containing not over 25 to 30 per cent of carbon, is gasified without any difficulty from clinkering or tar.

The main feature of the Jahns system is that no fuel is charged into the producer during the time of gasification, and that a number of producers is connected by means of channels to one unit.

The individual producers of the total unit are charged at certain intervals after each other, ignited, gasified without recharging, disconnected, discharged, recharged and reconnected. The tarry gases of the younger producers are drawn through the oldest producer. The necessary combustion air is simultaneously drawn in at the bottom of the producers. At the time when the youngest producer is ignited, the oldest is in full incandescence and the upper part of its content is—by the influence of the heat of the lower part and of the connected producers—coked to such an extent that the combustion of the upper layer will furnish gas free of tar.

If now during this period the gas of all the younger producers is drawn through the oldest, all the gas leaving the system will be free of tar. When the oldest producer is burnt out it is disconnected or, if it is not burnt out perfectly, connected with the next younger producer, through which now all the gases are drawn. During this period the upper layer of this producer is sufficiently coked and free of tar.

The gas from such a system will be the purer, the greater the number of the individual producers contained in the unit.

The gas production is continuous; the burnt-out producers are disconnected without interfering with the others, and the gas production is not influenced by the removal of the clinkers.

Figs. 1 to 3 show a Jahns producer plant which is in operation at the coal mine Von der Heydt, near Saarbruecken, Germany.

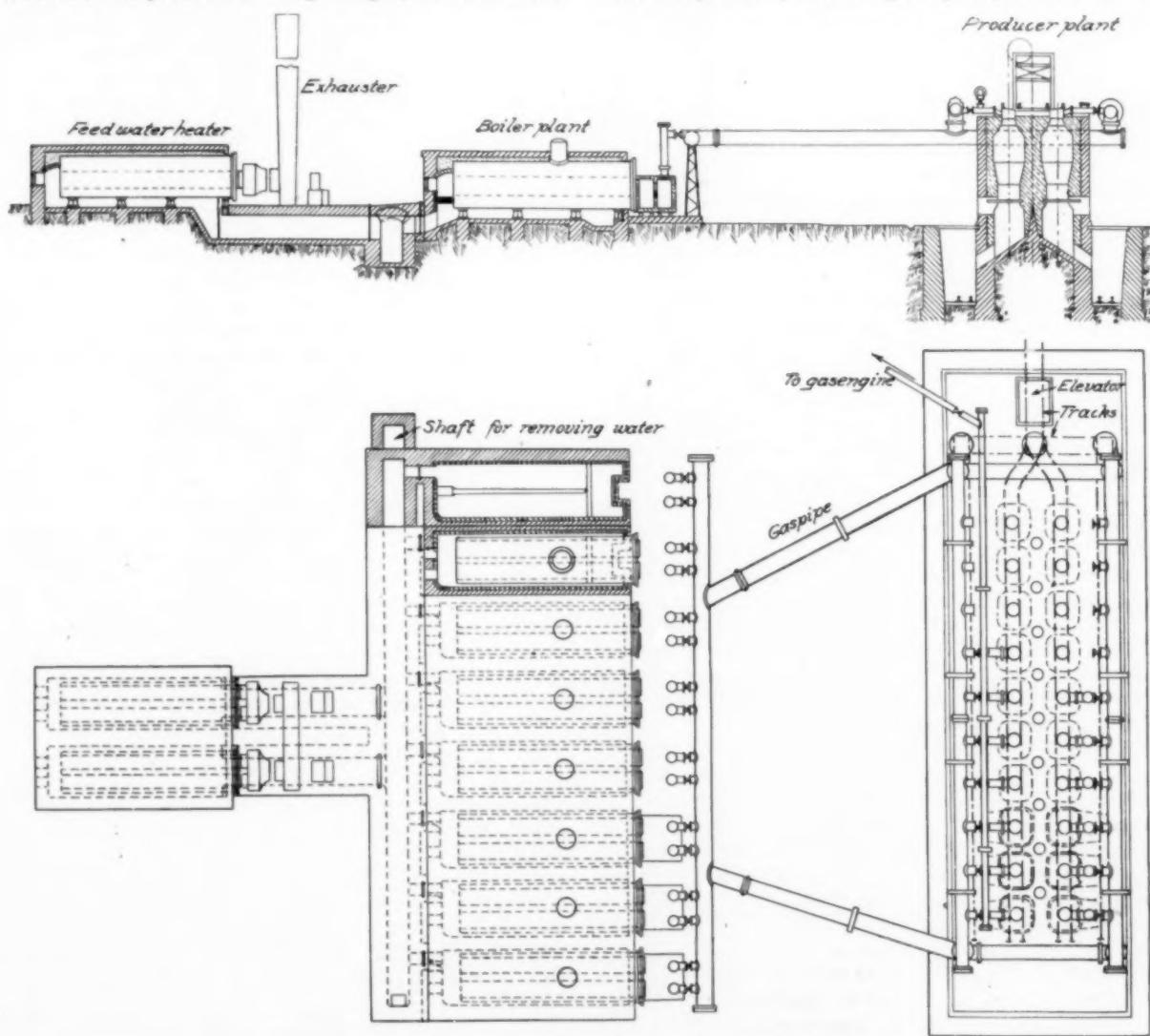
Each four producers have at the intersection of the separating walls a common vertical channel, with regulable openings into the same at the top and at the bottom. The main gas pipe is connected with an exhauster. The grate bars are removable, so that the ash can fall down. The ash pits are closed by means of doors.

When the first producer is being charged, its connections

the fourth producer is connected and ignited and the gases of the fourth, third and second producer are passing through the first producer. The latter has been burning now for about three-fourths of its period, is very hot and has its upper layer perfectly coked, being thereby enabled to liberate the passing gases from tar.

If the upper part of the charge is burnt out so far that the passing gases are not fixed any more, the gas-outlet valve and the lower valve of the second and the upper valve of the first producer are opened and the gas-outlet valve and lower valve of the first producer closed. The gases from the first, fourth and third producer now go through the second producer to the main gas pipe.

The first producer, after being completely burnt out, is dis-



FIGS. 4 AND 5.—ARRANGEMENT OF PRODUCER PLANT AND BOILER PLANT.

to the channel are closed and the connection to the gas main opened. The charge is ignited by a wood fire and slowly burnt. After about one-fourth of the burning period of this producer, the second producer is started, its ash door and the upper channel connection and the lower connection to the first producer opened. The gas from the producer II. now goes downward through the vertical channel, upward through producer I. and passes with the gases of the latter to the main gas pipe. As soon as the first producer is burnt down about one-half, the second about one-fourth, the third producer is ignited in the same manner and connected with the vertical channel.

The continuous gas production of the unit begins when

connected by closing the upper valve; the grate is drawn and the clinkers pushed into the ash pit. Then the bars are put back, the producer charged, ignited and by opening the upper valve connected again with the unit. The former part of the first producer is now taken by the second producer, which is continuing the production of fixed gas.

Each producer has a capacity of 4 to 5 tons. The fuel is charged into the producer by means of dump cars. The first ignition is effected by a wood fire and afterwards by the incandescent clinker contained in the ash pit. Gasification starts immediately after charging. The burning period of a producer charged with fuel containing about 75 per cent of carbon is 96 hours, charged with fuel containing 25 per cent

of carbon 48 hours. Perfect burning-out is effected by blowing steam into the producer after the gasifying period or by allowing the residuum to burn out perfectly in the ash pit, the gas formed thereby rising up into the producer.

The gas so obtained contains 7 to 9 per cent CO_2 , 16 to 20 per cent CO , 18 to 22 per cent H_2 , and 1 to 4 per cent CH_4 .

Any material containing carbon will furnish producer gas by means of this apparatus, no matter how high the content of ash or volatile substances. The percentage of tar in the gas produced is remarkably low, so that very little scrubbing is required to make it fit for the use in gas engines.

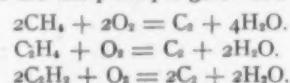
Smoke Abatement.

The Chamber of Commerce of Syracuse, N. Y., has just published a long report of 42 pages by its committee on smoke abatement. The chairman of the committee is Dr. JOHN A. MATTHEWS, of the Crucible Steel Co. of America, while the other members of the committee are Messrs. JOHN H. BARR (Smith Premier Typewriter Co.), W. H. BLAUVELT (Semet-Solvay Co.), CARLETON A. CHASE (Syracuse Chilled Plow Co.), WILLIAM KENT (Syracuse University), J. D. PENNOCK (Solvay Process Co.) and JOHN E. SWEET (Straight Line Engine Co.). The report should attract attention far beyond Syracuse, not only on account of the concise and exact statement of the principles underlying perfect combustion and smoke abatement, but because these principles are explained in such clear language as to be understood by the general public. After various introductory notes the principles of combustion and the causes of smoke are summed up.

"When coke, which has its carbon in the form of fixed carbon, or anthracite coal, which contains only 5 or 6 per cent volatile matter, is burned on a boiler grate, the air drawn through the spaces between the lumps of fuel by natural draft readily brings about complete combustion of the fuel to carbonic acid gas; this proceeds with no difficulty and without smoke, provided an initial temperature of 700° C. ($1,300^{\circ}$ F.) is furnished and an adequate supply of air passes through the bed of the fuel. With bituminous coal, however, containing 22 to 35 per cent volatile hydrocarbons, the process of combustion is quite different. Supposing the mass of fuel on the grate to be incandescent and a fresh charge of bituminous coal is made, what takes place?

"That portion of the coal next to the hot coals begins immediately to give off steam from the water in the coal and hydrocarbons follow and pass through the coat above, and are reduced in temperature; it is likely that the air at this time is insufficient on account of the choking of the pores in the firebed; or if there is air enough, it is too cold for ready combustion of the gases, or is imperfectly mixed; the hydrocarbon gases reach the cold boiler tubes, where they are further chilled and only partial combustion takes place; the carbon being precipitated in the form of soot, is carried along with the fire gases to the stack, and is expelled as black smoke. Complete combustion of these hydrocarbons can be effected only under the following conditions:

"First, a temperature sufficiently high, about 670° C. ($1,240^{\circ}$ F.), to bring about instant ignition of the gases; second, a sufficient supply of air, preferably heated, to combine with the carbon and hydrogen of the gases, but not a large excess of same; third, a good mixture of the air and hydrocarbons. Unless these conditions are strictly observed only partial combustion will take place, and carbon will separate according to the following reaction of air upon methane, ethylene and acetylene, which are the principal gases evolved:



"Carbon, soot or smoke thus formed can be burned with

very great difficulty; its formation must be prevented. This is possible by increasing very largely the amount of fire-brick in the furnace, which, by its incandescence from heat stored up and a sufficient supply of air, will burn the gases without precipitating free carbon.

"To the inexperienced, heavy masses of black smoke indicate a large loss of fuel. The loss, however, is not as great as it would seem. At a large boiler plant in this vicinity careful tests of the carbon in smoky waste gases were made, which showed that the plant was losing not more than 1 per cent of the fuel value of the coal in the smoke itself, but at the same time the unburned gases may have caused great loss.

"While, undoubtedly, black smoke is injurious to the health of man and damages property of all kinds, there is in waste gases from factory chimneys still another ingredient which is also injurious to health and which cannot be eliminated, namely, sulphurous acid, formed during the combustion of coal. The bituminous coal for boilers may contain as high as 1.5 to 2 per cent of sulphur, which is converted into sulphuric acid by the process of combustion; while a small percentage of this is combined with ammonia, formed from the nitrogen of the coal, the major part escapes as acid into the air."

The direct cause of smoke thus is that the gases distilled from the coal are not completely burned in the furnace before coming in contact with the surface of the boiler, which chills them below the temperature of ignition. The quantity and density of smoke depend upon many variable causes. Anthracite coal produces no smoke under any conditions of furnace. Semi-bituminous, containing 12.5 to 25 per cent of volatile matter in the combustible part of the coal, will give off more or less smoke, depending on the conditions under which it is burned, and bituminous coal containing from 25 to 50 per cent of volatile matter will give off great quantities of smoke with all of the usual old-style furnaces, even with skillful firing, and this smoke can only be prevented by the use of special devices, together with proper methods of firing the fuel and of admission of air.

Smoke may be prevented from forming if each particle of smoky gas, as it is made by distillation from coal, is immediately mixed thoroughly with hot air, and even if smoke is formed by the absence of conditions for preventing it, it may afterwards be burned if it is thoroughly mixed with air at a sufficiently high temperature. It is easy to burn smoke when it is made in small quantities, but when made in great volumes it is difficult to get the hot air mixed with it unless special apparatus is used. In boiler firing the formation of smoke must be prevented, as the conditions do not permit of its being burned.

As to the possibilities of preventing smoke, the first is to obtain anthracite coal. If this is not commercially practicable then one should try to obtain, if possible, bituminous coal with the smallest amount of volatile matter. The following special remedies are discussed in detail:

(1) **Proper Hand Firing.**—The general opinion in Europe is that while the efficacy of many mechanical devices cannot be denied, yet skillful and careful stoking is of first importance. This means firemen must receive a proper training. There are schools for firemen in Europe. On the other hand, in view of the fact that in America no specific and uniform instruction is available for the firemen, the various mechanical devices appear to offer the greatest immediate relief in this country.

(2) **Steam Jets.**—"There are many forms of application of the steam jet to boilers. Sometimes the steam is applied below and sometimes above the grate. Below the grate the effect is perhaps slightly to increase the draft, but mainly to soften the clinkers. Above the grate the steam jet is essentially for the purpose of inducing a draft of air over the fire and to mix the air with the gasses from the coal. The steam itself is not a source of any heat."

"Many devices for smoke prevention which are based on the use of the steam jet are of little value, and seem to be made only to sell. Others are carefully worked out in their details and are really of use, especially when properly applied to meet the special conditions, when combined with a device for automatically adjusting the supply of air to the volume of gases produced. Based on the fact that the volume of gases is great immediately after fresh coal is charged and slowly falls off until the next firing, these devices open a damper above the fire immediately after the closing of the fire-door, and by a dash-pot arrangement this damper is slowly closed, thereby regulating the supply of air between the maximum and minimum amount needed."

"A number of such devices are in successful use, and when properly applied and operated will prevent smoke. The cost of their installation is low compared with stokers, but they effect economy in coal consumption only to the extent to which they more perfectly burn the gases by the admission of neither too little nor too much air to meet the varying requirements of the fire." While such steam jet devices can prove effective in the reduction of the volume of smoke, yet they should not be expected to result in any considerable economy of fuel; "on the other hand, unless properly operated they are quite apt to increase the cost of operation."

(3) **Hawley Down-Draft Furnace.**—The principle utilized in the operation of this furnace is not unlike that of the under-feed stokers, inasmuch as the volatile hydrocarbons pass through the green fuel before reaching the combustion zone.

The result is that the volatile gases are intimately mixed with the supply air as they are distilled off and the conditions are favorable for complete combustion when these gases attain the ignition temperature. The Hawley down-draft furnace was described and illustrated in our Vol. IV., p. 177.

The report states that "plants of moderate capacity, too small to make the installation of mechanical stokers advisable, may quite effectively reduce the formation of smoke, and with good economy, by the use of down-draft furnace. This is particularly the case when the fuel is of a favorable quality, the draft is good and the demand for steam is such that the boilers are not necessarily forced at times much beyond their normal capacity." It is claimed by the makers of the Hawley down-draft furnace that it will save from 10 to 20 per cent in the fuel; that it will increase the boiler capacity and that it will reduce the smoke emitted 90 per cent.

(4) **Mechanical Stokers.**—There are four types of mechanical stokers. First, the forwardly inclined grate, of which the Roney stoker is an example. Second, the "V" shaped grate, of which the Murphy stoker is a representative. Third, the under-feed stoker. Fourth, the chain grate.

"From the point of view of smoke prevention the automatic stoker is merely a means for feeding the coal uniformly into the fire, and thereby maintaining uniform conditions, and therefore uniform production of hydrocarbon gases. Uniform conditions make it much easier to maintain perfect combustion of the hydrocarbons, and hence to prevent smoke, but very many installations of automatic stokers smoke very badly, oftentimes quite as badly as furnaces with poor hand-firing."

"In order to prevent smoke, it is quite as necessary to maintain the proper conditions for good combustion with stokers as without them. To insure these conditions, it is customary to build a fire-brick arch over the stoker, either in the shape of a 'Dutch oven' in front of the boiler setting, which is usually the better plan where room permits, or the arch is thrown across the fire-box between the fire and the boiler. It is usually quite difficult to maintain an arch in this position owing to the high temperature to which the brick work is subjected on both sides, and many devices have been put forward to maintain these arches. One type, which appears so far to be quite successful, consists of special shaped bricks, which are perforated so that air from the outside is permitted to

travel the whole length of the arch within the chambers or flues formed by these perforations, and is delivered, considerably heated, at the rear end of the arch, where it supplies the air for the final combustion of the gases. The heat absorbed by this air keeps the bricks sufficiently cool to prevent their destruction. The 'Dutch oven' construction has the advantage that this arch is free to radiate its heat through the top, and it is, therefore, relatively easy to maintain."

The use of mechanical stokers not only reduces the quantity of smoke emitted but effects a considerable saving over hand-firing, and "with large enough a plant a fair return on the investment for mechanical stokers can be reasonably expected."

But all devices to bring best results should be carefully handled. In some cases a bonus to the firemen has produced good results, but owing to the weakness of human nature the permanent effectiveness of such measure is somewhat doubtful. Continuous carbon-dioxide indicators have been used as a means of determining such a bonus, and in large plants these devices have produced good results.

The recommendation of the Committee as to the installation of smoke-abatement devices are three. First, the purchaser should put the burden of responsibility upon the firm installing the device. Second, the plans for new steam plants should be submitted to some competent authority for approval. Third, success in smoke prevention can only be obtained through the hearty co-operation of the coal users themselves, and this co-operation on the part of the owner of every steam plant is earnestly requested.

A circular letter sent by the Committee to manufacturers in different cities asked the questions whether the manufacturer considered that in making his installation of smoke-preventing devices he had made "a sacrifice to public sentiment." To this question thirty-two replied no, and of ten who said yes only five were using mechanical stokers. Another question was whether the manufacturer considered that "the good accomplished in smoke abatement is worth while the cost to manufacturers, hotels, etc." Thirty-two said yes, two said no and six were in doubt. The Committee considers this very strong evidence that the manufacturers themselves do not think that they have been oppressed. While the question of smoke abatement may be considered from the aesthetic standpoint, yet the economical point of view should be most strongly emphasized, and it should be clearly understood that in many cases it will be possible to solve the problem of smoke abatement with simultaneously improving the efficiency of operation.

The Detinning Suit.

It seems that the detinning suits are bound to become one of the most celebrated and complicated litigations on engineering matters ever witnessed in this country. On page 46 of our Vol. IV. we recorded the decision of the lower courts in the suit of the Vulcan Detinning Co. against the American Can Co. in favor of the latter, and on page 345 of our Vol. V. we recorded the decision of the higher court reversing the former decision.

In the meantime a suit has been begun by the firm of Theodor Goldschmidt, in Essen, Germany, against the Vulcan Detinning Co., asking the court to enjoin the latter company from operating their electrolytic detinning plants. It will be remembered that while the firm of Theodor Goldschmidt was no part in the first suit, the secret electrolytic detinning process invented by Dr. Hans Goldschmidt and the mode of importing the secret process to other countries are at the bottom of the whole controversy. The details will be found in our former articles referred to above. The suit was recently continued to Feb. 24.

The Goldschmidt Co. is represented by Mr. Halsey M. Barrett and Mr. Hubert E. Rogers, the Vulcan Co. by Messrs. McCarter and English.

The Manufacture of High-Grade Steel in the Electric Furnace.

The progress which electric refining of steel is making in Germany and the attention which it attracts is indicated by the fact that three different articles on this subject appeared during the month of November in *Stahl und Eisen*. An article by Prof. Wedding, the Nestor of German steel men, dealing with new developments of the induction furnace, is given elsewhere in this issue. In another very interesting article in *Stahl und Eisen*, Nov. 20 and 27, the problem of steel refining in general and in the Héroult furnace in particular is discussed by Director O. THALLNER, of Bismarckhütte, in Upper Silesia.

Mr. Thallner first discusses at great length the possibilities of producing high-grade steels in ordinary metallurgical furnaces. The following two general classes of processes have proven commercially successful. First, chemically very pure ores are treated and a chemically very pure and qualitatively very good pig iron is produced which is then treated to produce high-grade steel. Secondly, the starting material is of a less pure quality, which is treated by a combination process; either first in the puddling furnace and then in the crucible or open-hearth, or first in the converter and then in the open-hearth and perhaps also in the crucible.

Processes belonging to the first kind are very much more expensive than those belonging to the second kind. Nevertheless the former processes have held their own, although the products of both kinds of processes, according to their chemical analysis, are often claimed to be of equal excellence. In view of the price difference of the products it must be concluded that there is a difference in quality. But then it is clear that chemical analysis, as now made, does not give conclusive evidence as to quality.

As to industrial analysis, all steel works determine phosphorus. Sulphur and copper are often determined, but not always. Arsenic is determined in few cases. When sulphur is determined, it is not determined whether it is dissolved or exists in combination with iron or copper or arsenic. But worst of all, industrial chemical analysis does not indicate the rôle which oxygen plays in steel; it does not state whether the oxygen, if determined, comes from a chemical compound with iron, or from a solution or emulsion or slag rest, or from included gas or oxides. Under these circumstances the determination of oxygen does not give any indication how deleterious its effect may be. There is very little known as to the soluble oxides, though it is known that dissolved oxides are a very important factor in determining the quality of the product. This is especially the case with respect to the formation of blow-holes and pipes.

Mr. Thallner produces considerable evidence to show that dissolved ferrous oxide, the chief carrier of hydrogen, very considerably increases the alloying capacity of the iron with hydrogen. The surest means to prevent the deleterious effect of hydrogen on blow-hole formation is thorough deoxidation.

Mr. Thallner then refers to Braune's investigation of the influence of nitrogen in iron (our Vol. V., p. 51). He does not agree with Braune's conclusions, since Braune treated his steel in an atmosphere of ammonia, not of pure nitrogen; hence he had both hydrogen and nitrogen. Mr. Thallner produces some evidence to prove his conclusion that if we deoxidize the bath by means of carbon, then the escaping carbon monoxide gas also removes the nitrogen.

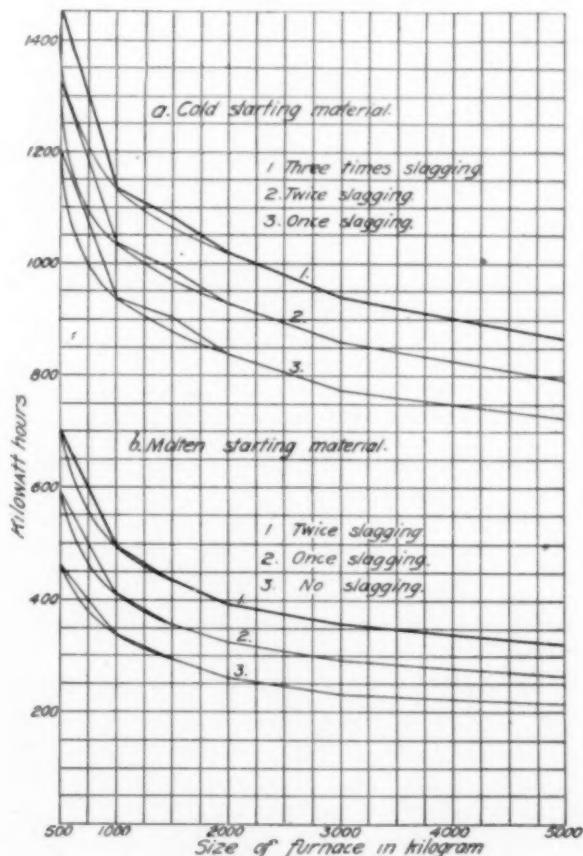
The net result of the general discussion of Mr. Thallner is that it is of chief importance for progress in steel manufacture to remove completely all deleterious impurities, and that a very important step in the right direction will have been accomplished, if we can do this with sulphur, slags and oxides.

As long as we know as little as we do now concerning the physics of the problem (structure, etc.) the only way to make further progress is to produce a chemically absolutely pure

material. The purer chemically a product is the higher its quality. But the determination of chemical purity must not be restricted to the determination of phosphorus, sulphur, arsenic and copper, but must be broader, and special attention must be paid to the oxides.

In passing over to a discussion of the electric steel furnace, Mr. Thallner remarks that the electric furnace has often been compared in the past with the crucible furnace, and has been considered simply as a melting furnace. But there is a great difference between these two types of furnaces. As used heretofore the electric furnace, with its basic lining, is simply a basic furnace for smelting under absence of fire gases but not under absence of air. The chemical processes in it are different from those in the acid crucible, since in the electric furnace there is no silica nor its gradual solution, reduction and the continuous effect of the silicon on the deoxidation under absence of air.

If in a crucible furnace the crucible would be used without a



ENERGY CONSUMPTION IN HEROULT STEEL FURNACE.

cover, it would be simply an imitation of the acid open-hearth furnace, and it would be necessary to employ a slag in order to protect the metal from the direct influence of the fire gases. But then we would have the disadvantage that the ferrous oxide in the slag would be oxidized to ferro-ferric oxide, and would then be able to give off oxygen to the metallic bath. Then we would lose the principal characteristics of the crucible process, namely, the long lasting period in which the metal is left at rest, with simultaneous mechanical removal of the oxides, their reduction in the metal by silicon and the simultaneous removal of gases. This process cannot be obtained in the basic open-hearth furnace nor in the acid open-hearth furnace nor in the electric furnace, nor would it be possible in the basic crucible.

The electric furnace is, therefore, different from the crucible furnace and must be considered as a distinct apparatus.

Further, the electric current should be considered simply as a source of heat, though as a very clean and easy source of heat. It had been thought that the electric current would have a direct desulphurizing effect, since it permits to keep the metal for any length of time at a high temperature. It is true that sulphur is able to migrate and is easily oxidized and can be removed by heating, roasting, etc., if it is present in large quantities, but it is impossible to go in this way below a certain limit. For this reason it is difficult in the open-hearth furnace to fix the moment at which the desulphurization is complete. It is possible only by repeated renewal of the slag, the fresh slag added being free from sulphur.

If at any stage of the open-hearth process a few tenths of a per cent of tungsten or molybdenum are added to the bath, the content of sulphur will decrease considerably, but also the content of these metals. As soon as they disappear the content of sulphur increases again. Tungsten and molybdenum are strong desulphurizers also in the crucible. The desulphurizing action is due to the fact that their oxides are able to combine with the sulphur, so that these oxides with the sulphur pass into the slag. The oxides are not reducible therefrom, but evaporate. The iron oxides of the slag do not evaporate, they combine eagerly with the sulphur and phosphorus, and the latter participate in any reduction process which removes iron from the slag. With respect to sulphur it must therefore be said that it cannot be removed by long heating with a slag rich in iron, because the latter prevents the diffusion of the sulphur into the air.

To desulphurize, it is necessary to have a slag free from iron. Since a slag free from iron cannot be maintained continually in the open-hearth furnace, it is difficult to remove the sulphur with certainty by means of a slag as long as it is rich in iron, since it also absorbs eagerly sulphur from the fire gases, and this sulphur is brought back into the bath by any reduction process.

It is, therefore, clear that to desulphurize the presence of a slag free from iron is of chief importance. The possibility of thorough refining of steel in the electric furnace essentially rests in the possibility of completely mastering the slag composition and formation in the electric furnace, for the purpose of obtaining absolute chemical purity.

"The recognition of this fact is to be placed to the credit of the three men—Héroult, Eichhoff, Lindenberg—and their work should not simply be recognized but should be praised openly as great, important and obtained by persistent effort." With respect to controlling the slag, Mr. Thallner thinks the electrode furnace, and especially the Héroult furnace, to be specially suitable, because there is here the possibility of concentrating the maximum energy of electrical heat within the slag. Not even calcium resists the temperature of the arc, and it is possible to produce here very fluid and highly basic slags, as is hardly possible in any other process.

The process in the Héroult furnace consists essentially of three stages. In the first stage the phosphorus is removed, the conditions being about the same as in the open-hearth furnace, although far more favorable. At the same time the sulphur is considerably reduced, but not nearly to the same degree as the phosphorus. Further, the content of carbon decreases below 0.10 per cent. Manganese and silicon are also almost completely removed. This first stage shows the phenomena of over-oxidation.

The second stage is deoxidation. Mr. Thallner remarks that he is not permitted to describe this stage, which is *per se* only an acceleration of deoxidation under absence or without use of manganese and silicon. This stage is preparatory for the third stage.

The third stage is the reduction process. The object is to deoxidize the slag by formation of calcium carbide and silicon carbide, to reduce the iron from the slag and to keep the slag free from iron so as to make it permeable for the sulphur. In this period the desulphurization takes place with greatest

certainty and quickly down to practical trace. But a second effect is also obtained, because on account of the possibility of lengthening the period of melting we can get free from the slag emulsions, while new oxygen cannot come from the air into the bath, as the content of iron in the slag is continually reduced. The traces of sulphur which are simultaneously reduced are enabled to migrate again outwards and in connection with the calcium to evaporate and to be oxidized by the air. Naturally in this stage of greatest freedom from oxides, the addition of carbon may be carried out without reducing deleterious constituents of the slag. The steel can be finished free from oxides.

"The advantages of this metallurgical process may be simply summed up as the following three effects: First, dephosphorization; second, desulphurization; third, deoxidation to a degree which is never possible with the same amount of certainty in other processes using equally impure starting materials. This is an established fact and represents a progress the importance of which should not be under estimated."

Of course, the process requires careful work and extra cost, and the author warns optimists from thinking that they can now produce and sell high-quality steels without paying for it.

The first 1.5-ton Héroult furnace in the Lindenberg works in Remscheid has stood 2337 charges (between four and ten a day), cold and molten charges alternating irregularly and intermittently, and according to Mr. Lindenberg no essential repairs have become necessary. The slag does not attack the furnace. When the furnace has been emptied it is at once ready again for a new charge. Small repairs, if necessary, require neither considerable time nor great expense. The operation of the Héroult furnace requires more conscientious attendance than hard work. The accompanying diagram shows the consumption of energy when starting with cold and with molten metal. The curves give the consumption of energy in kilowatt-hours per ton of steel for different sizes of the furnace.

Other diagrams given by the author on the basis of 307 charges with molten metal and forty charges with cold metal, show that in practical operation the certainty with which the impurities can be held below predetermined limits is very great.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

THE UNAUTHORIZED USE OF SCIENTIFIC PUBLICATIONS AND THE ABUSE OF PROFESSIONAL REPORTS.

A recent unauthorized use of the proceedings of the Institution of Mining and Metallurgy has evoked a stern reminder that use shall not be made "of the discussions on papers or other subjects at the meetings of the Institution, in prospectuses or any other documents published in connection with commercial undertakings, without the written authority of the Council, and of each individual speaker or writer concerned previously obtained."

It is a regrettable fact that in only too many cases technical papers are written which have as a reason for their appearance some ulterior commercial objects. New processes must, of course, be described and discussed, but the greatest care should be taken that no written law or unwritten law of etiquette should be violated.

Of greater importance than this is the frequent abuse of technical reports, and the Council therefore consider "that all members should insist upon their reports and other documents connected with commercial undertakings, whenever published: (1) being distinctly dated; (2) being published in

extenso, or (3) if summarized, the summary to be approved and signed by the member concerned.

This valuable rule may well be commended to other than metallurgists. It is only too frequent that the honesty of a detailed report is rendered of no avail because of the selection and publication of isolated statements by interested parties.

THE EXACT MEANING OF TECHNICAL TERMS USED IN METALLURGICAL WORK.

The Council of the Institution of Mining and Metallurgy is to be congratulated on their bold stand regarding the manner in which certain technical terms should be used. As regards a great many estimates and measurements, it cannot be said in the words of one of Mr. Kipling's rhymes "There are nine and sixty ways * * * * and every blessed one of them is right." Upon the subject of the term "ore in sight" so prominent in mining prospectuses and in reports from mine managers, the Council of the Institution of Mining and Metallurgy have come to the following wise decision:

"1. That members of the Institution should not make use of the term 'ore in sight' in their reports, without indicating, in the most explicit manner, the data upon which the estimate is based; and that it is most desirable that estimates should be illustrated by drawings.

"2. That as the term 'ore in sight' is frequently used to indicate two separate factors in an estimate, namely:

"(a) Ore blocked out—that is, ore exposed on at least three sides within reasonable distance of each other—and

"(b) Ore which may be reasonably assumed to exist though not actually 'blocked out,'

these two factors should, in all cases, be kept distinct, as (a)

is governed by fixed rules, whilst (b) is dependant upon individual judgment and local experience.

"3. That in making use of the term 'ore in sight' an engineer should demonstrate that, the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

"4. That all the members of the Institution be urged to protect the best interests of the profession by using their influence in every way possible to prevent and discourage the use of the term 'ore in sight' except as defined above; and the Council also strongly advise that no ambiguity or mystery in this connection should be tolerated, as they (the Council) consider that such ambiguity is an indication of dishonesty or incompetence."

The Institution have also adopted some definitions of weights and measures. These were printed on page 512 of the December issue of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY.

THE STANDARDIZATION OF SCREENS.

The Institution of Mining and Metallurgy issued, in their November Bulletin, a report on the standardization of screens by Mr. Walter McDermott (who acted as chairman of their mesh standardization committee), and also a list of I. M. M. standard laboratory screens for use in making grading tests and for the correlation of screens used in commercial or other work. (These were printed on page 512 of the December issue of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY.)

The Council decided that the only practical improvement on existing conditions would be the establishment of a standard set of laboratory screens, obtainable by all engineers, to be based on a uniform proportion between the number of meshes and the size of aperture, so that the great convenience of description by mesh could be retained, with a recognized equivalence of aperture.

A great deal of consideration was given, first to the relative sizes of wire and aperture to be adopted; and second to the number of screens which should be included in the standard table. On the first point a number of makers of wire cloth

were consulted; and it was decided that the adoption of equal size of wire and aperture would, in the majority of sizes, give the best screen, having the minimum tendency to shifting of the wires, and giving apertures corresponding fairly well with some of the similar mesh screens already in use in laboratories.

As regards the number of standards, the Council had to choose from a great variety of suggestions. Some engineers, recognizing the disadvantages of unnecessary refinements, advocated a small number of screens; while others were in favor of a long list, from which an engineer could select his own. The table which has now been accepted is a compromise between the extreme views.

To those who would prefer to see a greater number of sizes, it may be pointed out that not only does the manufacture of a large number of standards itself create an objection, but the introduction of unnecessary refinements in sizing by screens is not justified by the real accuracy of the process. Variations in ores, in methods of crushing, and in the personal equation, combined with irregularities, even in the most careful weaving of the cloth, all destroy actual accuracy; and in addition to this, excessive refinements in sizing are impossible in practical working of ore, and are not required therefore in the laboratory. If an engineer desires to use some special screen for reasons of his own, and if he describes it by the size of aperture, it will be easy to note its relation to the standard sizes of the table, by its position between two of these sizes.

In the preparation of the standard I. M. M. screens, the Council, recognizing the importance of reducing to a minimum the irregularities in manufacture above referred to, and knowing that a number of makers could not be expected to take the necessary precautions in the preparation of the small quantities of screening required for merely laboratory purposes, decided that it was advisable to get a good stock manufactured at one time by one maker, with one drawing of wires to the required gages.

This has been now in part carried out, and means will be taken to supply all makers of wire cloth and dealers in laboratory equipment, with any number of sets of the cloth in squares of 8 in. or made up in nesting frames clearly marked with the mesh number, and the size of aperture in decimals of in. and mm. Enlarged photographs of some of the first sample sizes submitted are very satisfactory as regards the limited irregularity of the openings compared with ordinary commercial wire cloth; and thus, incidentally to the main object of uniformity of practice, an increased degree of accuracy of sizing will probably be secured.

WEAR AND TEAR IN ELECTRIC FURNACES.

A short note in the current number of the *Electrical Review* gives some information of a kind badly needed in regard to electric furnaces. At the beginning of last July the 1,500 kilogramme Heroult electric furnace employed at Lindenbergs steel works, in Remscheid, turned out its 2,000th charge. The furnace has been at work continuously since March, 1906, treating a charge previously melted in a Siemens-Martin metallurgical furnace. The dolomite bed of the Heroult furnace was repaired after every charge, but in other respects the furnace has lasted well, requiring only a new cover made of silicious material once every three to seven weeks.

THE FINANCES OF THE CASTNER-KELLNER ALKALI CO., LTD.

The shareholders in this undertaking are certainly situated more fortunately than those in the Electrolytic Alkali Co. which works the Hargreaves-Bird patents, whose disappointments I chronicled last month. The net profits of the Castner-Kellner undertaking for the year ended Sept. 30, after the usual expenditure in maintaining works, plant and machinery, was £116,754.11.5, which with £14,773.6.1 brought forward, makes £131,527.17.6 Debenture and other interests absorbed £9,697.8.2, and the interim dividend at the rate of £8 per

cent for the six months ended March 31, £18,000, leaving £103,830.9.4. The directors recommend that £30,000 be placed to depreciation reserve, writing £15,910 off plant and machinery and £7,500 off suspense account, the payment of £36,000 in dividends for the six months ended Sept. 30, making 12 per cent for the year, and leaving £14,420.9.4 to be carried forward.

MARKET PRICES DURING NOVEMBER.

The price of tin at the beginning of the month was £146.10 per ton, it fell to £135.5 on the 7th, and rose to £142 on the 12th, falling again to £134.10 on the 18th, slight irregularities occurred until £139 was reached on the 25th.

Lead opened at £18.18, and after varying from this value to £18.10 up to about the middle of the month, fell continuously, reaching about £18 at the end of the month.

The price of copper on Nov. 1st was £68 per ton, this being the highest price reached for some days. It fell to £59 on the 8th, rose to £61 on the 11th, fell to £59 on the 13th,

followed by some irregularities until the 20th, when it stood at £58, reaching £62 on the 25th, and closing at from £63 to £64.

Cleveland pig iron was 51/- per ton on the 1st Nov., it fell to 49/3 on the 5th, and rising with slight irregularities to 51/- again on the 14th, dipping to 50/3 on the 19th, rising to 51/- again on the 20th, fell to 49/10 on the 22d, where it remained until the 26th.

Hematite was 70/10 per ton on the 1st November, it fell irregularly to 68/- on the 8th, at which price it remained until the 11th, thus rising slightly with a few irregularities, and finally falling to 67/10 on the 27th.

The price of antimony at the end of the month was £36 to £38 per ton.

Copper sulphate was £23.10 per ton; ammonia sulphate, £12.5 per ton; bleaching powder thirty-five per cent, £4.10 per ton; white caustic soda seventy-seven per cent, £11.26 per ton, and shellac £11 per cwt.

London, Dec. 7, 1907.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

IRON AND STEEL.

Electrolytic Manufacture.—G. Hofer, in *Giesserei-Zeitung*, 1907, page 140 (*Revue de Metallurgie*, November), describes a process for producing pure iron, or pure manganese, or alloys of these metals. The oxides are soluble in melted calcium fluoride; such a solution, with the addition of more fusible fluorides, is electrolyzed, using enough current to keep the bath melted and also the deposited metals. More oxide is added as the bath needs replenishing. Carbon anodes are used, and loss of metal by volatilization is avoided, because it rests as a melted cathode at the bottom of the bath. Silica present is reduced, and the silicon escapes as fluoride, SiF_4 ; phosphorus is also volatilized. Ores rich in silica and phosphorus may thus be utilized. To economize on current, mixtures of oxides and reducing carbon should be made, so as to diminish the current required. Without such a suggested scheme, the cost of current for pure electrolysis would be prohibitory; with such a scheme, the whole project reduces itself to a simple electric furnace reduction of iron ores, using a fluoride of calcium flux.

Chromium Tool Steel.—Léon Guillet has recently examined a new tool steel accidentally made in the electric furnace by adding double the charge of chromium intended. The data are given in *Revue de Metallurgie* for November. The analysis showed C 2.18, Cr 14.88, Mn 0.71 and Si 0.19 per cent. The normal steel was found under the microscope to consist of perlite with a double carbide of iron and chromium, the latter in sort of fibers. It cannot be rolled, and can be forged only with difficulty. It casts into clean ingots. To fit for use it is heated to 950°, cooled in air to 850° and then quenched in oil, when intended to cut steel; when to be used for cutting cast iron, it is heated to 1,050°, cooled in air to 950° and then quenched in oil. These tools give remarkable service, particularly in planers, being only slightly inferior to the expensive rapid tool steels containing tungsten or molybdenum.

Hardness of Tool Steels.—M. Demozay, in *Revue de Metallurgie* for September, contributes a study of the hardness of tool steels of the following percentage compositions:

No.	C.	Cr.	W.
4	1.5	2.5	...
5	2.0	...	6.0

No.	C.	Cr.	W.
6	0.5	1.5	10.0
7	0.5	3.5	12.0
10	0.6	2.8	8.0
11	0.7	3.8	7.8
12	0.9	6.0	22.0

The soft steels, slowly cooled, were heated to various temperatures and then quenched in water, oil or by air blast. The hardness was determined by the Guillery apparatus, using a sphere pressed into the test piece by 4 tons hydraulic pressure and measuring the diameter of the impression. A simple 1.1 per cent carbon steel has a maximum hardness when quenched in water at 850° C.; when quenched in oil it is nearly uniformly half as hard as water-quenched, but has a maximum hardness also at about 900°. Steels 6, 7, 10 and 11 showed maximum hardness when quenched at 1,200°; steel 5 is hard at starting, and becomes intensely so when quenched at 1,000°, the billet becoming warped and cracked.

Simple 0.9 per cent carbon steel was tested for its variation in hardness with temperature. It was found to get softer up to 100° C., then harder to about 250°, then uniformly softer as the temperature rises. Tempered chrome steel, with 2 per cent chromium shows no such minimum or maximum, but gets uniformly softer as the temperature rises. At 450°, however, it is still harder than the plain 0.9 carbon steel is at zero. Musket steel, specially treated, is as hard to start with as chrome steel, rapidly softens until only half as hard at 100°, then as rapidly increases in hardness, until at 250° it is about equal to its hardness at 50°; from 250° up to 500° its hardness is nearly constant, only slightly diminishing, and at 500° it is still as hard as the chrome steel at 250° to 350°. This behavior is a distinct peculiarity of musket steel. This steel, if untreated, or if annealed, becomes distinctly harder at 100° to 150°, at 300° to 350° has about the same hardness as at 0°, and then slowly gets softer. The modern high-speed steels all become harder up to 250°, then slowly fall off, but at 400° are still nearly as hard as when cold; in fact, some retain this same hardness up to 500°. The curves and detailed data of the original paper are too extensive to be reproduced, but contain valuable information for steel makers and users.

COPPER.

Alloys with Cobalt.—The physical and mechanical properties of a few alloys of these metals have been studied by Berthier and Guillemin and Reichart, but N. Konstantinow is the first to study the field systematically. His paper is in *Revue de Metallurgie* for November. The electric conductivity of copper decreases rapidly and regularly with increase of cobalt up to 5 per cent, then falls regularly, but much more slowly, to a minimum at about 90 per cent cobalt; after this, as pure cobalt is approached, the conductivity rises regularly and rapidly. The author considers this as proving the existence of solid solutions at 5 per cent cobalt and 10 per cent cobalt, with mechanical mixtures of these with copper, cobalt or each other at other proportions.

In studying the fusing points, pure copper and cobalt, melting at $1,084^{\circ}$ and $1,505^{\circ}$, respectively, were melted together in magnesia crucibles in an atmosphere of hydrogen or nitrogen, using a kryptol electric furnace. The fusing point of copper is raised with increase of cobalt up to 6.5 per cent, which appears to be the limit of solid solution of cobalt in copper, melting at $1,110^{\circ}$. The melting point then rises rapidly to 30 per cent cobalt at $1,370^{\circ}$; from here to 65 per cent cobalt the setting point is constant at $1,370^{\circ}$, with a lower arrest of temperature at $1,110^{\circ}$, showing these alloys to be simply mixtures of 35 per cent copper in solid solution in cobalt with 6.5 per cent cobalt in solid solution in copper. These alloys always form two layers of different composition if allowed to stand. Over 65 per cent cobalt the upper melting point rises rapidly to pure cobalt at $1,505^{\circ}$. Photomicrographs were made of polished sections etched by HCl for alloys rich in copper, or by FeCl_3 solution for alloys rich in cobalt. The alloys with 5 cobalt, 95 copper and 10 copper, 90 cobalt showed the best grain and looked like the best alloys.

ALLOYS.

Composition and Electromotive Force.—N. Pouchine, in *Revue de Metallurgie* for October, presents some deductions upon the constitution of alloys as determined by their electromotive force in solutions of acids or alkalies. The principle is employed of not reading momentary differences of potential but only those which are approached asymptotically after several hours observation. Under these conditions the constitution of the alloys tested is brought out very strikingly. The following is a summary of the results and conclusions: *Silver-selenium* measured against Ag in $1/7$ N. AgNO_3 solution showed very plainly Ag^2Se . *Silver-tellurium*, similarly tested, showed Ag^2Te . *Copper-tellurium*, tested against Cu in $1/1$ N. CuSO_4 , shows evidence of both Cu^2Te and CuTe , giving between them solid solutions. *Lead-tellurium*, examined in $1/1$ N. PbN_2O_4 solution, shows the existence of PbTe , which gives solid solutions with Pb but not with Te. *Tin-tellurium*, in $1/1$ N. H^2SO_4 solution, the compound SnTe is found. No definite compounds were found in alloys containing *tin-bismuth* or *zinc-cadmium*. *Copper-zinc*, the curve was studied in $1/1$ N. ZnSO_4 solution against Zn, and showed clearly and decisively the compounds Zn^2Cu , Zn^4Cu , ZnCu and ZnCu^2 . These conclusions are different from those obtained by previous investigators, but the potential curves point clearly to their presence. *Zinc-silver*, in the same electrolyte, these showed Zn^2Ag , Zn^4Ag , Zn^8Ag , ZnAg doubtful, ZnAg^2 . *Zinc gold* similarly examined, these showed Zn^2Au , Zn^4Au , ZnAu and solid solutions between Zn^2Au and Zn. *Copper-cadmium*, studied in both $1/1$ N. CuSO_4 and $1/1$ N. H^2SO_4 , showed solid solutions of Cd and Cd^2Cu , Cd^4Cu , solid solutions of Cd^8Cu and Cu. *Copper-tin*, in $1/1$ N. H^2SO_4 , showed clearly SnCu^2 and SnCu^4 , but no sign of CuSn , which was said to exist by Heycock and Neville. *Silver-tin*, similarly tested, showed only SnAg^2 . *Copper-silver-tin* in the same electrolyte, it appears that in Ag^2Sn or Cu^2Sn the copper and silver can mutually replace each other without destroying the identity of the alloy; it appears that there may exist in these alloys, Cu^2Sn , Cu^4AgSn , CuAg^2Sn and Ag^2Sn .

Gold-tin in $1/1$ N. H^2SO_4 shows the existence of Sn^2Au and SnAu , with solid solutions between Sn and Sn^2Au . *Copper-aluminium* shows the existence of AlCu only. *Aluminium-silver* shows only AlAg . *Antimony-bismuth* shows a series of isomorphous mixtures in $1/1$ N. KOH. *Antimony-zinc* shows only Zn^2Sb^2 and ZnSb , with no solid solutions in the system. *Tin-arsenic* in $1/1$ N. H^2SO_4 shows very clearly Sn^2As^2 and SnAs , analogous to the preceding alloys. *Tin-antimony*, tested in normal SnCl_3 , H^2SO_4 and KOH, showed in all cases SnSb only. *Silver-antimony* in $1/1$ N. KOH shows Ag^2Sb and Ag^4Sb . *Nickel-antimony* in $1/1$ N. KOH shows Ni^2Sb and NiSb . Alloys of lead with Cu, Ag, Bi, Sb and As showed no definite compounds or combinations; solid solutions were found only in the lead-antimony alloys. *Tin-nickel*, tested in normal SnCl_3 , H^2SO_4 and KOH solutions showed only SnNi . *Tin-cobalt*, similarly tested, showed SnCo . *Tin-manganese* in $1/1$ N. KOH gave only one compound, SnMn^2 . *Tin-iron* in the same solution gives clearly SnFe^2 and no other compound. *Tin-chromium* shows neither compound nor solid solutions.

ALUMINIUM.

Aluminium.—F. G. A. Wilm claims, according to the *Brass World* of November, to be able to increase the strength and ductility of aluminium by chilling. In order to produce satisfactory results the aluminium, or the aluminium-copper alloy, must be chilled at a temperature between that at which the alloy becomes solid and a point not more than 30° below the recalescence point. When this temperature is reached the alloy is immediately chilled in cold water. The recalescence point was determined for copper aluminium alloys with various percentages of copper. For 1 per cent Cu it is 485° C., for 2 per cent 501° C., for 3 per cent 512° C., for 4 per cent 524° C., for 6 per cent 530° C., for 10 per cent 535° C., for 15 per cent 538° C., and for 33 per cent 540° C. For example, in case of an alloy of aluminium containing 4 per cent of copper, the point of solidification is 640° C., while the recalescence temperature is 525° C. The point at which the alloy must be heated previous to chilling, therefore, lies between 495° and 640° C.; by applying the method to this alloy cast in a chill mold the tensile strength was increased 48 per cent and the elongation 2 per cent. With sand castings nearly the same increase was found, and with wire sheet and rod the method likewise produced the same results.

SILVER.

Silver from Silver Chloride.—An anonymous writer in the *Brass World* of October has used the soda-ash method, but has abandoned it on account of the corrosive action of the soda-ash on the crucible and the frothing of the mass. He now uses the method of reduction by iron with subsequent melting of the reduced spongy silver. The silver chloride is placed in a tub filled with dilute sulphuric acid and pieces of clear wrought iron (or of galvanized iron clippings) are brought in contact with it. Iron dissolves and the silver is deposited as a gray powder. It is dried and melted. In order to reduce any stray particles of chloride of silver that may have escaped reduction a small quantity of soda-ash is used in melting it.

CALCIUM.

Calcium Hydride as Reducing Agent.—Dr. F. M. Perkin and Mr. L. Pratt's Faraday Society paper, which was already briefly noticed in our last issue, dealt with the reduction of metallic oxides by calcium hydride.

When copper oxide is mixed with calcium hydride in proportions corresponding to $2\text{CuO} + \text{CaH}_2 = 2\text{Cu} + \text{CaO} + \text{H}_2\text{O}$, and ignited by means of a match, a vigorous reaction ensues, and volumes of steam are given off. On cooling a black mass is obtained, which on treatment disintegrates, owing to solution of calcium oxide, and metallic copper in a state of fine division is obtained. Pyrolusite, haematite and tin stone all behave in a similar manner. Zinc oxide appears not to be

reduced. Lead sulphide and antimony sulphide both react vigorously, and during the reaction the mixture swells up considerably, rising up out of the crucible in a cylindrical form. Very little metal is produced, the bulk of the product being a dark gray mass, which appears to be a compound of the metal with calcium and sulphur.

Borax and boric anhydride also react with calcium hydride when the mixture is strongly heated in the muffle furnace. Silica in the form of fine sand only reacts after prolonged heating, but reaction takes place more readily when kieselguhr is employed. Wolframite and rutile only react with difficulty.

Experiments were also tried with metallic calcium and wolframite. In this case a particularly vigorous reaction takes place, the tungsten being melted and being obtained on cooling as a hard regulus. The heat is so great that the calcium oxide is also melted. Rutile is also reduced by calcium; the reaction, however, is not so intense, and the titanium and calcium oxide are not fused.

The action of metallic calcium upon metallic chlorides was also studied. Manganese chloride and cadmium chloride are readily reduced. When metallic calcium and strontium chloride are mixed together in molecular proportions and ignited by heating in an iron crucible by means of the blow-pipe reaction ensues:



Very little metal, however, is obtained, probably owing to the formation of a sub-chloride, $\text{Cl}_2\text{Sr} = \text{CaCl}$. On adding two atoms of calcium the reaction is intensely vigorous, and the metal is obtained as a fused regulus. With barium chloride the reaction is less vigorous. With the alkali metals very vigorous reactions also take place.

MISCELLANEOUS.

Fluxes for Soft Metals.—A long illustrated article on the choice and use of fluxes for soft metals will be found in the November issue of the *Brass World*. The three principal soft metals are lead, tin and zinc. Various combinations of them are used in commerce, but what is said about the individual metals applies equally to the alloys. Mixtures in which there is considerable zinc, however, must be fluxed with sal-ammoniac in the same manner as pure zinc. The whole subject is summed up in the following table:

Metal.	Best Flux.
Tin	Tallow.
Lead	Rosin.
Solders	Rosin.
Lead alloys	Rosin.
Tin alloys	Rosin.
Zinc	Sal-ammonia.
Zinc alloys	Sal-ammonia.

In the case of tin or tin alloys, rosin will be found better than tallow for making solder or babbitt metal, but if tinning is to be done, tallow should be employed. The method of using fluxes on soft metal is as simple as it possibly could be. The rosin, sal-ammoniac or other flux is sprinkled upon the surface while the metal is melted. No more than is necessary to clean the metal is used. The liquid scum is then skimmed off.

The Platinum Group.—L. Holborn, in an address before the British Association (*Revue de Metallurgie*, November), discussed at length optical pyrometry, and gave as the results of his most recent optical measurements, based on the validity of Wien's law, the following:

Palladium	$1,585^\circ \pm 10^\circ$
Platinum	$1,790^\circ \pm 15^\circ$
Rhodium	$2,000^\circ \pm 20^\circ$
Iridium	$2,400^\circ \pm 25^\circ$

ANALYSIS OF CURRENT ELECTRO-CHEMICAL PATENTS.

ELECTRIC FURNACES.

Electric Furnace.—G. Holmgren, 873,861, Dec. 17, 1907. Application filed March 6, 1907.

The design of the furnace is based on the principle of electric generators with revolving field system and stationary armature. A two-pole single-phase generator furnace is shown in Fig. 1 in vertical and horizontal section. "The furnace has a U-shaped upright armature core 1 around the vertical shanks, of which the melting bath 2 of the furnace forms two closed circuits communicating with each other. The rotatable field magnet 3 has a vertical shaft 4 and two poles of segmental shape corresponding to the shape of the pole surfaces of the

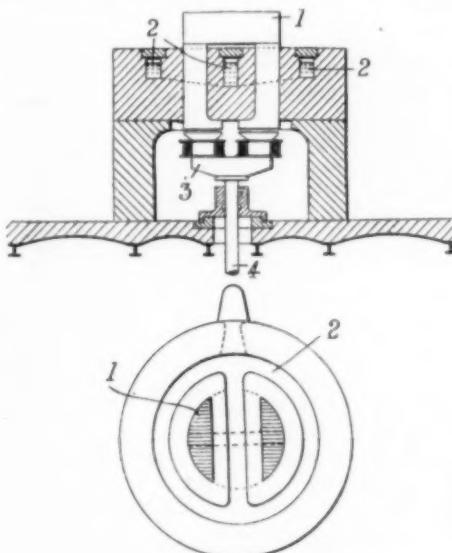


FIG. 1.—ELECTRIC FURNACE.

armature core. When the field magnet 3 is in the position shown in the illustration in relation to the armature core, the magnetic circuit is closed through both circuits of the melting bath. When the field magnet has been turned 90° from the said position, each half of the magnet circuit of the same is closed through one of the armature poles, so that the magnetic flux does not pass through the closed circuits formed by the melting bath. Nevertheless, it is possible, by giving the pole pieces suitable dimensions, to keep the total magnetic flux through the air gap between the field and armature cores substantially constant. The variation of the number of lines of force inducing the melting bath and of those short circuited by the pole pieces of the iron cores takes place successively, whereby vibrations in the iron cores will in a very high degree be avoided and the self-induction of the furnace will be comparatively low."

Refining of Steel.—G. O. Seward and F. von Kugelgen, 874,628, Dec. 24, 1907. Application filed July 6, 1907. Assigned to Virginia Laboratory Co.

The feature of the process is that no carbon electrodes are used, but the electrodes are pencils of the pig iron which is to be refined in contact with a proper slag. Pig iron is cast into blocks or into any suitable shape and two such electrodes are connected to the circuit. The heat is produced either by the resistance of the slag to the passage of the current, or by an arc between the metallic electrode and the slag or by a combination of both. The pencil melts off gradually and the metal collects at the bottom of the furnace, the refining being partly effected as the electrode melts, and partly as it lies at the bottom of the crucible under the refining slag. "The re-

fining effect is quick and complete, and no recarburization is possible. It is possible to use a much more oxidizing slag than would be possible with carbon pencils, because a slag containing a great deal of iron oxide would attack a carbon pencil seriously, but would have only a good effect in refining a metal pencil as it melted. It is also possible, as we have no carbon in the furnace, to introduce air as in the Bessemer process, and thus assist in burning out the impurities from the metal to be refined. A combination of Bessemer and electric effect is thus secured."

Tantalum.—M. von Pirani, 873,958, Dec. 17, 1907. Application filed March 18, 1907. Assigned to Siemens & Halske Co.

Homogeneous coherent bodies of tantalum can be produced by smelting in an electric arc furnace. The tantalum to be smelted is placed on the positive electrode. The furnace is exhausted. A long and powerful arc may be started in the vacuum without bringing the electrodes first in contact, if the residue of gas remains in the vacuum furnace is first ionized. The ionization is effected by a metallic oxide being placed in the furnace and heated. The oxide is preferably connected with the cathode and the heating is most simply effected by means of a platinum wire embedded in the oxide, and which is brought to incandescence by passing an electric current through it. Barium oxide is particularly suitable. With an interval between the electrodes of several centimeters and a tension of about 100 volts, an arc may be produced with a current of 50 amps. sufficient to melt the tantalum.

Electric Furnace.—William R. Parks, 873,890, Dec. 17, 1907. Application filed April 11, 1907.

The peculiarity of the furnace which is shown in Fig. 2 rests in the construction of the electrodes. C is a hollow tube electrode, the furnace charge passing from the hopper D through the hollow electrode downwards into the furnace. G is the other electrode, and has at its top a circular gutter g, in which the molten metal and slag collect and are drained off through several downwardly extending drain openings k into the fore-hearth K.

ELECTROLYTIC PROCESSES.

Copper from Sulphide Ores.—C. H. Ehrenfeld and J. R. Grove, 866,849, Sept. 24, 1907. Application filed Sept. 7, 1906.

To recover copper from copper sulphide ore, for instance, chalcopyrite, the ore is pulverized to about 30 mesh; it is heated in an atmosphere with a limited supply of oxygen for the purpose of expelling the sulphur and of converting the metalliferous substances of the ore into the lower oxides of the metal. The copper is then dissolved out of the ore, with or without the aid of electricity, into an aqueous solution of ammonium chloride, and the metal is finally deposited by the electric current out of the solution. The extraction from the ore and the deposition may be carried out in the same cell, the pulverized ore being placed in bulk upon and around the anode. Mechanical circulation of the electrolyte is not recommended.

Diaphragm Cell.—A. E. Gibbs, 874,064, Dec. 17, 1907. Application filed June 2, 1906.

The construction of the cell is shown in Fig. 3. The outer vessel 2 of sheet steel is provided with an annular flange 3 around its top on which rests the projecting annular ring portion 4 of the cathode. A lower disc 5 is provided with an

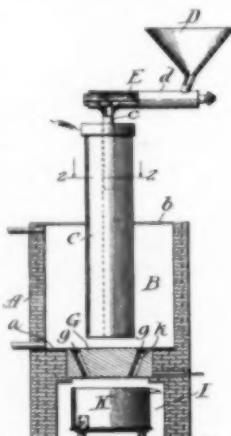


FIG. 2.—ELECTRIC FURNACE.

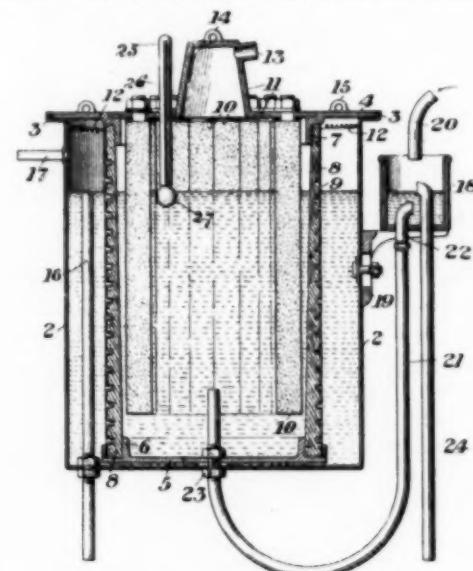


FIG. 3.—DIAPHRAGM CELL.

upwardly projecting flange 6 of the same diameter as 7. Around the registering flanges 6 and 7 a barrel is formed consisting of the permeable diaphragm 8 jacketed by the cylindrical cathode 9. The diaphragm may be formed of asbestos. The metallic jacket which forms the cathode is made of sheet steel and is provided with a series of projections on one face and is perforated. The anode consists of a series of carbon rods 10. The feeding apparatus is as follows: 20 is the inlet pipe, feeding solution into the cup, while 21 is the flexible rubber tube connected to a pipe 22 within the cup, having a lateral inlet at one side. The flexible tube 21 leads through the bottom of the casing 2 and through the disc 6 being held

by the clamp connection 23. The cup is provided with an overflow pipe 24 which maintains a substantially constant level in the cup. A visible indicator of the height of the liquid in the cell is provided in form of the tube 25, which is closed at the top and open at the bottom and extends above the dome far enough to allow the stem 26 of the float 27 to be seen. The bulk of the cathodic electrolytic action takes place at the projections of the cathode; and as the caustic is formed there, the flow of electrolyte carries it outwardly through the holes of the cathode and out of the region of electrolytic action. The advantages of the invention are believed to result particularly from the cathode having points or projections entering the diaphragm.

Nickel from Nickel Sulphide.—J. N. Spring, 874,864, Dec. 1907. Application filed Nov. 8, 1906.

By a chemical process of purification (see description under Recent Metallurgical Patents) nickel sulphide is obtained which is treated in a diaphragm cell as follows. Both compartments of the cell are filled with nickel chloride solution; the cathode consists of nickel, the anode of graphite. The nickel sulphide is fed into the anolyte and is held there more or less in a state of suspension or is fed in a thin layer down the flat faces of the anode. The "nascent" chlorine combines with the nickel from the sulphids, so that practically no chlorine gas is evolved at the anode. Sulphur gradually accumulates in the anode chamber, from where it is periodically removed and separated from the sulphides, for instance, by sublimation. Nickel is deposited on the cathode in a fine coherent form.

Manufacture of Nitro-Cellulose.—G. C. de Brialles, 874,564, Dec. 24, 1907. Application filed March 10, 1906.

This is an electrolytic process in which the losses and the dangers of manipulation in the manufacture of nitro-cellulose are avoided. It is carried out in a cell shown in Fig. 4. The

receptacle is formed of strengthened glass. The closure at the upper part is effected by a glass cover or stopper. This reservoir is furnished at its convex base with a branch 8 and a glass delivery valve 9. Towards the middle of the height of the reservoir on the interior of the wall a circular projection 10 is provided, strong enough to support a porcelain partition 11. Upon this partition, perforated with a number of holes, 12, is highly heaped the cellulose 13 to be nitrated. The reservoir is filled with a suitable mixture of concentrated sulphuric acid and ordinary nitric acid. A thermometer 14 is provided in the lower part of the cell; 16 and 17 are the positive and negative electrodes, respectively, being made of platinum or gilded platinum wire. They constitute a rheostat to moderately heat the liquid. "The active surface of the negative electrode must

be smaller than that of the positive electrode, so that the quantity of nitric acid involved will be the least possible. In order to obtain a good nitration of the cellulose it is necessary to have in solution a small quantity of nitrous acid, which is produced by the action of the hydrogen in contact with the negative electrode and the nitric acid." An excess of nitrous acid can be detected by the coloration of the liquid. In this case the surface of the negative electrode must be reduced, for instance, by enveloping part of it by asbestos cloth or spun glass. The cellulose immersed in the mixture of the two acids

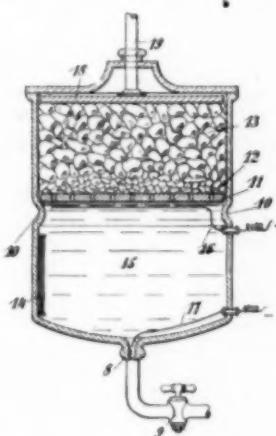


FIG. 4.—MANUFACTURE OF NITROCELLULOSE.

is nitrated in about 3 or 4 hours if the temperature does not fall below 30° C. In any case it ought not to exceed 40° C. After the completion of the process, the liquid is drawn off by a pump attached to a delivery tube, and "by the aid of porcelain disc 18, forming a piston mounted on a neck of the same material adapted to engage in a flexible stopper 19 of india rubber, a strong force can be exercised on the cellulose, in order to expel the absorbed acids." After all the liquid has been drawn off the cell is filled with water and the nitro-cellulose is washed until no longer any vapor is given off. The receptacle is then opened and the nitro-cellulose is submitted to further washings in the open air.

Electrodeposition.—W. Mueller and C. R. Murray, 874,374, Dec. 17, 1907. Application filed May 13, 1904.

Mechanical details of apparatus for electrodepositing metals for type matrices.

BATTERIES.

Primary Battery.—C. E. Hite, 857,880, June 25, 1907. Application filed Nov. 15, 1904. Assigned to Hite Electric Company.

To provide for proper circulation of the electrolyte through the different cells of a battery, the electrolyte in each of the cells communicates through the open bottom with a reservoir of electrolyte, common to all cells, and situated below the battery. By means of a pumping arrangement a flow of the electrolyte is caused from the reservoir upwardly through the cells, and then downwards upon the outside walls.

Primary Battery.—C. E. Hite, 858,391, July 2, 1907. Application filed Dec. 23, 1905. Assigned to Hite Electric Co.

This is a modification of the same general idea mentioned in the preceding patent. Claim 3 of patent 858,391 reads as follows: "In a primary cell, the combination of a receptacle having a plurality of compartments at its upper end and a reservoir beneath the compartments, the compartments open at the top and bottom, a pair of electrodes in each compart-

ment, an electrolyte common to reservoir and compartments, means for conducting the electrolyte from the compartments, as it becomes partially exhausted, to the bottom of the reservoir without mingling with the fresh electrolyte in the upper part of the reservoir, and means for conducting said fresh electrolyte from the upper part of the reservoir to the upper part of said compartments."

Primary Battery.—C. E. Hite, 858,392, July 2, 1907. Application filed Dec. 28, 1905. Assigned to Hite Electric Co.

The cell consists of three parts, vertically above each other. The middle part contains the set of electrodes inserted in porous mass of depolarizing material and incased in a coating of porous material, so as to form a solid porous block. The upper part of the cell is empty; the lower is filled with the electrolyte. When the cell is to be used, the whole cell is inverted and the electrolyte percolates gradually through the porous mass between the electrodes. When the whole electrolyte has percolated through and the cell is required to operate longer, it is again inverted.

Storage Battery.—C. Busch, 873,715, Dec. 17, 1907. Application filed June 25, 1907.

Claim 2 reads as follows: "In an electrical accumulator, an element consisting of a metallic envelope, formed of a sheet of substantially non-corrosive metal, folded so as to form a tube, active material contained within the said tube and the ends of the said envelope folded in so as to inclose the said active material, perforations in the walls of the envelope and a capillary lacing passing through the perforations and uniting the opposite walls in the manner of a sinuous winding."

Primary Battery.—H. C. Thomson, 866,748, Sept. 24, 1907. Application filed Dec. 21, 1903.

A circular battery zinc (a zinc cylinder with a slit) generally corrodes first at the water line. In order to prolong the life of the zinc the inventor provides the open edges of the slit with lips turned back toward and almost touching the zinc plate itself.

DISCHARGES THROUGH GASES.

Nitric Acid from Air.—H. Pauling, 873,891, Dec. 17, 1907. Application filed April 6, 1906. Assigned to Salpetersäure-Industrie-Ges.

When atmospheric nitrogen has been forced into combination with oxygen by heating air to a sufficiently high temperature (for instance, by means of electric discharges), it is important to cool the gas mixture quickly so as to prevent the dissociation of the nitrogen oxide formed. For this purpose it has been proposed to cool the gas mixture by blowing passive or indifferent gases into the gas mixture. Instead of any passive gas, the inventor employs part of the gas mixture produced before by the process. In this way the dilution of the gas mixture by inert gases is avoided.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Chilled Castings.—C. J. Mesta (874,018, Dec. 17, 1907. Assigned to Mesta Machine Co.) has found that in the manufacture of articles of chilled cast iron the castings become more dense and tough and the depth of the chill is increased by the addition of a small percentage of vanadium to the chilling iron which is cast in the chill mold. For chilled rolls one-quarter of 1 per cent gives excellent results. The elastic limit and tensile strength is increased, the fatigue limit is increased, the wearing qualities are increased, and finally the roll will better resist expansion and contraction.

Treatment of Low Grade and Impure Ores.—Many non-Bessemer ores are highly silicious, and do not make good basic pig iron, and these ores are frequently high in sulphur, or, in some cases, the only fuels available for smelting them are

high in sulphur. With such ores and such fuels, in ordinary practice if the furnace is run hot, a silicious pig iron is produced which cannot be easily handled in a basic furnace. If the furnace is run cold, a sulphurous pig iron is produced which cannot be easily freed of impurities in the basic open hearth. This is especially true in the absence of manganese in the ores, a very frequent condition. H. O. Chute, of Cleveland, Ohio (874,391, Dec. 24, 1907), proposes to treat such ores by the following process: By using an excess of fuel, as compared with the ordinary smelting operation to produce basic pig iron in the blast furnace and thereby running such furnace very hot, the inventor states he can charge it with an ore mixture containing manganese and phosphorus, both preferably added as by-products resulting from a later operation, and with enough lime to make a basic slag, and thereby almost completely eliminate sulphur in the slag as manganese sulphide, producing a very hot and fluid pig iron, rich in silicon and phosphorus, all the phosphorus of the charge appearing in the iron. About half the manganese of the charge also appears in the iron, and such iron is practically saturated with carbon. The product of this operation is a highly silicious, very hot pig iron, which may be termed superheated, while the sulphur is mostly eliminated in the basic slag. This superheated iron can be readily desiliconized by dusting iron oxide on it. The silicon and manganese are removed, and the carbon begins to be attacked, while the phosphorus remains in the iron. The slag is skimmed off. The purified skinned iron is still essentially pig iron, but is now largely freed from silicon, sulphur and manganese, but contains large amounts of carbon and phosphorus, rendering it an excellent material for treatment in a basic open-hearth furnace for removal of the carbon and phosphorus. The slag from the desiliconizing operation, which is silicate of iron and manganese, and the phosphoric slag from the open-hearth are returned to the blast furnace, as described above, so that the iron from the slag is recovered and the manganese and phosphorus are used over again. If manganese be absent in the ore, some must be procured. In running the furnace hot with sufficient fuel to produce the described pig iron, a rich gas is obtained, which may be advantageously employed in the auxiliary desiliconizing furnace and in the basic open-hearth furnace.

NICKEL.

Refining Nickel.—John N. Pring (874,864, Dec. 24, 1907) patents a process of refining crude nickel. As applied to the separation of nickel from copper refining waste in the form of crude sulphate, the process is as follows: The crude sulphate is dissolved in water to which is added a little sodium sulphide or nickel sulphide. The solution is agitated and filtered. Copper is thrown out as sulphide, together with As, Sb, Bi, Pb and Hg. The filtrate is then digested with an alkaline sulphide, black ash or calcium sulphide, and Ni, Co, Fe, Zn and Mn are precipitated as sulphides. Without separating these sulphides, the agitated liquor is digested with an acid to the point of neutralization. An excess of an acid, like hydrochloric acid, is then added, and after agitating for a short period it is found that nickel sulphide and cobalt sulphide alone remain undissolved. These are thus recovered: They may be further treated by electrolysis, as described in an abstract of the Analysis of Current Electrochemical Patents, in our present issue.

BLOWPIPE.

Oxy-Acetylene Blowpipe.—C. Delcampe, of Quincy, Mass. (874,492, Dec. 24, 1907) patents mechanical details of construction of a blowpipe comprising two separate pipes, one for acetylene, the other for oxygen. The exit end of the oxygen pipe is arranged within the exit end of the acetylene pipe which forms the mixing chamber of the blowpipe head. Both pipes are provided with detachable nozzles of capacities of a definite relation. When it is desired to change the size of the

flame, both detachable nozzles are removed and replaced by other nozzles of different capacity, but having the same definite relation, which yields the proper mixture of oxygen and acetylene.

SMELTING PROCESS.

Carbon Dioxide as Reducing Agent.—While in ordinary smelting operations carbon monoxide is the chief reducing agent, J. C. Hardie, of Helena, Mont. (874,336, Dec. 17), claims to be able to accelerate the smelting process materially by employing a blast of carbon dioxide gas with the addition of steam. The carbon dioxide gas is generated outside of the smelting furnace in a special gas generator, and, mixed with steam, it is supplied to the melting furnace in form of a blast through the tuyeres.

GOLD AND SILVER.

Cyanide Process.—Sulphides and pyritic and arsenical ores are treated according to the process of F. M. Johnson (873,943, Dec. 17, 1907) by putting the ore into a tank containing a solution of caustic soda and some stirring device. "While in this tank and being agitated it is subjected to the action of an electric current of high amperage and low voltage, derived from any suitable source of electrical energy. The result of the combined chemical and electrical actions on ores of this character is to remove sulphur and arsenic, to remove any iron present, to wholly or partially dissolve any silver and to effect a general decomposition of the mass which puts it in better condition for the cyaniding." The whole mass is then passed directly to the cyanide tank, wherein the gold is dissolved by the cyanide while the caustic soda continues its solvent action on the silver. When the gold and silver have been extracted from the ore, precipitation is carried out not with the customary zinc shavings but by means of simple plates of zinc and aluminium, which are bound together with copper strips. A flat plate of zinc is used between two flat plates of aluminium riveting copper strips around the ends, so as to bind all together into a single structure. With a plate of this character a perfect precipitation of both gold and silver is effected. If the ore requires no preliminary treatment, and is placed directly into the cyanide tank, caustic soda solution is added to the latter, so that the proportions of the caustic soda and the cyanide are about "equal in volume."

ALLOYS.

Chromium-Cobalt and Chromium-Nickel.—E. Haynes (873,745, Dec. 17, 1907) proposes the use of a chromium-cobalt alloy for articles requiring a high and durable lustre and possessing a high degree of hardness and resistivity to corrosion and oxidation, so as to be suitable for standards of weights and measures, etc., as a substitute for platinum, etc. It also possesses a high degree of hardness, so that it may be used as a substitute for mild tempered steel in the manufacture of edged tools such as table and pocket cutlery, physicians' and dentists' instruments, etc. The alloy is best worked into the desired form when heated to red heat. Alloys containing between 10 and 60 per cent of chromium may be employed. An alloy of 10 per cent of chromium with 90 per cent of cobalt has satisfactory hardness while not being brittle, but is not so resistive to corrosion as an alloy containing from 25 to 30 per cent of chromium. While an alloy containing 30 or more per cent of chromium is best suited to edged tools and like instruments. It is important that the metals are free from carbon, sulphur, etc. To produce the alloy a very high temperature is required; either the oxyhydrogen flame or the electric arc or the aluminothermic method may be employed. The same inventor (873,746, Dec. 17, 1907) has found that an alloy containing from 30 to 60 per cent of chromium and 70 to 40 per cent of nickel has similar properties. It may be best worked cold. The higher the proportion of chromium the harder is the alloy and the greater its resistance to tarnishability.

RARE METALS.

Purification of Tungsten, Etc.—Tungsten, molybdenum, tantalum, vanadium, chromium, etc., may be purified to such a degree of purity as to be suitable for incandescent lamp filaments, etc., by the following method of C. van Brunt (873,809, Dec. 17, 1907. Assigned to General Electric Company). For the purification of tungsten trioxide WO_3 , the inventor first prepares a solution in which this oxide becomes an alkaline tungstate. This may be done by fusing the oxide in alkali, such as Na_2CO_3 or by boiling it with an alkaline solution. The solution is then filtered and acidified with HCl to neutralize the alkali. This must be done with care, and the quantity of acid to be used should be such as to give approximately a molecular ratio of HCl to WO_3 = 1.5. If care is used the product is characterized by the ease with which it may be washed and filtered. The acidified solution is fractionally precipitated by a solution of benzidine-hydrochloride. The impurities present appear to be largely concentrated in the first fraction, the size of which is made dependent upon the amount of the impurities. In general it will not exceed a tenth part of all WO_3 present and may be much less. The second fraction is figured to contain the bulk of the WO_3 and is to be regarded as pure. It is necessary, however, that all of the WO_3 should not be precipitated, since otherwise impurities might be carried down. The tungsten precipitate is benzidine meta-tungstate. The hydration is small. The benzidine tungsten is then thoroughly washed with water and calcined at a low temperature in an unglazed porcelain crucible, whereby water and organic material are passed off, leaving only pure WO_3 . The latter is an impalpable powder, almost fluffy in lightness. Tungsten powder may be obtained from the WO_3 by reduction with hydrogen or otherwise and is exceedingly fine grained and uniform. By this method of purification the most minute traces of such elements as arsenic and iron are removed which would ruin the material for use in lamp filaments. In this way it is possible to purify a whole batch of oxide in a single day.

The New Recording Millivoltmeter and Shunt Ammeter.

Electrical engineers have long felt the need for an accurate and sensitive recording millivoltmeter, which is adapted to practical everyday service as well as for laboratory tests. There has also been a demand for a recording ammeter of the shunt type, which can be connected by leads to the main busbar. The shunt system is especially economical where heavy currents are to be indicated or recorded, as the instruments may be located at a considerable distance from the main circuit, thus saving great expense in carrying the main conductors to the point where the instrument is located. The recorders illustrated herewith have been designed to meet these practical demands.

The two most important fundamental features of these recorders are a sensitive electrical movement of special design made by the Weston Electrical Instrument Co., and a new recording system using a patented smoked chart, so arranged that there is absolutely no friction between the recording arm and the chart.

These instruments are so sensitive that the recording arm will move over the whole scale for 5 millivolts or less, making it possible to accurately record one ten thousandth of 1 volt. The graduations on the chart are evenly proportioned over the entire range, the same as the Weston ammeter, so that even though there is only a small current flowing, the readings may be as readily taken as if the current was the maximum that the instrument would record. This feature will be greatly appreciated, as there are many places where it is important that

the records be perfectly clear, even though the loads are very light when the outfit is first installed.

The records are made on a novel semi-transparent smoked chart, which is periodically brought into momentary contact with the end of the recording arm by means of a special vibrating device. In this way a series of white dots are made



FIG. 1.—RECORDING MILLIVOLT METER.

on the smoked surface, and these form a continuous line, and a record is thus made without causing any friction between the moving arm and the chart. The rate of vibration of the chart is timed to suit the frequency and range of the variation in the current to be recorded. The usual period of vibration of the chart is once in 10 seconds, but to obtain continuous lines where the fluctuations of the current are quite rapid, the vibrating attachment is made to operate twice every second.



FIG. 2.—CHART TAKEN IN UNDERGROUND ELECTROLYSIS SURVEY.

When the record is completed the chart is dipped in a simple fixitive solution which makes the record permanent for filing.

The recording millivoltmeter is shown in Fig. 1, and Fig. 2 is a reduced photographic facsimile of a chart taken from one of these instruments in connection with electrolysis surveys of underground structures which are being conducted by the Electrical Testing Laboratories of New York City. The graduations of this chart are arbitrary. It was revolved once in 24 hours and was vibrated once every 10 seconds. The

zero position of the recording arm was the middle of the scale, so that the record might be independent of the direction of the current, as in many cases the direction of the current changes from negative to positive during the day.

It is expected that by using a number of these instruments operating simultaneously at different points, stray currents in water and gas mains or in any underground structure may be recorded, making it possible to discover the causes of trouble and how they may be eliminated.

The recording ammeter is shown in Fig. 3 connected to a standard Weston 10,000-amp. shunt, to which is also connected a Weston indicating station ammeter. This illustration shows that the recorder may be readily applied to any standard shunt which is already in service, without disturbing the indicating instrument at the switchboard. As illustrated here, leads of almost any desired length may be used to connect the indicating and recording instruments to the shunt on the main bus-bar. It is even possible to have the recording ammeter located in the superintendent's office at a great distance from the shunt and the indicating instrument located on the switchboard convenient for the observation of the operator. Such

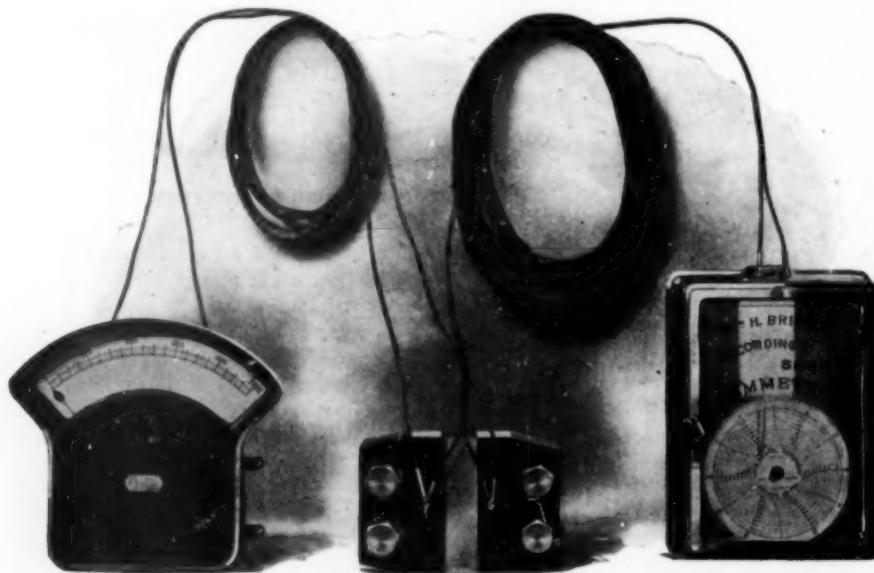


FIG. 3.—RECORDING AMMETER.

The recording shunt ammeter is connected to a 10,000-amp. Weston shunt, to which is also attached a Weston indicating station ammeter.

combination outfits could be furnished as units, with leads of the proper lengths to suit the individual cases.

The recording shunt ammeter has been successfully applied for taking continuous records of the current on a large trolley system, where the fluctuations are very rapid and varied as much as 4,000 amps. several times in a minute. The charts for such work as this are made to revolve once in 1 hour, and the vibrator operates twice in 1 second. For preliminary tests, the recorders are provided with special fast vibrators for the smoked chart and with a clock movement to revolve the chart once in 1 hour, but for continuous daily records the standard 24-hour charts are recommended.

These instruments are manufactured by William H. Bristol, 45 Vesey Street, New York City.

Color Photography.—At a meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on Dec. 20, Dr. Maximilian Toch presented a very interesting paper, illustrated by demonstrations and experiments on photography in the colors of nature. The subject was discussed by Dr. Toch along broad lines, but with special reference to the new Lumiere process.

Lead-Lined Iron Pipes.

The lead-lined and tin-lined iron-pipe industry was started in this country eighteen years ago by Mr. Thos. E. Dwyer, and has been carried on with steadily increasing success by the Lead Lined Iron Pipe Co., of Wakefield, Mass. This company furnishes at present over 100 water-works with pipe for all their services and thousands of feet of special pipe yearly for use on acids, etc.

The pipe is made as follows: A length of iron pipe is thoroughly pickled and



FIG. 1.—LEAD-IRON PIPE ELBOW.

given a bath of tin, which solders it inside and outside, making it, even before the introduction of the lining, a solid pipe which can have no pin holes in it. The lining of lead or tin is then introduced into the iron pipe by pouring molten lead or tin into it around a mandrel, and the lining is thoroughly fused onto the iron pipe, so that the whole pipe is one solitary unit. For this reason the pipe can be bent and cut and used roughly without any injury to the lining. The reasons why it has found so much favor with water-works are its cheapness, and the fact that the pipe may be put in a perfectly true line, or if desired may be just as easily bent to avoid rocks without injury to the lining. It may be cut and threaded as easily as any iron pipe. For water-works in whose districts there is danger of electrolytic action from the stray currents from tramway systems an extra heavy iron pipe is made,

which is, moreover, covered with a special coating. On account of the possibility of rough usage the tin-lined and lead-lined iron pipes are also largely used in buildings and houses.

In order to make the pipe applicable to all possible purposes, special fittings of all kinds are made such as lead-lined iron tees, tin-lined iron elbows, etc. Such an elbow is shown in Fig. 1. Lead-lined iron pipes are also very useful for boiler feed or hot water, as a pure lead lining does not corrode. It has also found wide application in pulp and paper mills, and the Lead Lined Iron Pipe Co. cut the pipe out to sketch of either wrought iron, cast iron or spiral riveted pipe with flanged or screwed joints.

For use with acids the joints on lead-lined iron pipes are flanged, thereby insuring a perfectly tight joint. Pure lead is

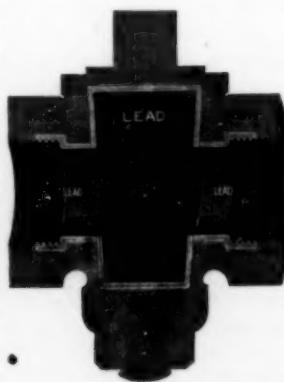


FIG. 2.—LEAD-IRON PIPE COCK.

used and the lead lining may be made of any thickness. Such pipes have been found very useful with all kinds of acids hot or cold. For use with hot acids hardened lead is employed. For pumping in mines and salt wells a special pump column pipe is made to stand any pressure specified. The joints are flanged together and the lead is recessed into the flanges to make the casket, making one continuous lead lining. These pump column pipes are in use in many of the largest copper and coal mines.

The same company makes lead-lined iron unions which need no washer, as the lead lining acts as that. The lining extends down into a portion of the threads, and there can be absolutely no corrosion. The lead is hardened and it can be used either with hot or cold liquids.

Fig. 2 shows a lead-lined iron stop cock. These cocks are either flanged or screwed, and they are lined with pure hard lead, which acids do not attack. The plug is made of an acid-resisting bronze, and the opening in the plug is thoroughly protected with lead. The plug part is made of bronze in order that it may work easier on the lead lining of the stop cock. It does not stick.

Lead-lined iron valves are made by the same company of the gate pattern; all interior parts being thoroughly protected with lead, so that corrosive acids or liquids have no chance to attack the iron. These valves have been subjected to the hardest kind of usage, both with salt water and acids, and have stood the test for the past eighteen years.

Besides lead-lined pipes the same company is now also making lead-covered coils, tubes and pipe, since there has been a constant growing demand for a pipe with a lead lining on the outside instead of the inside, the lining being fused to the outside in the same way as in the other type. Such pipes are, for instance, useful for passing steam through at a very high temperature while corrosive liquors are on the outside. These lead-covered coils are made of either brass, copper or iron.

Oxone and the Regeneration of Air.

As was already noticed in these columns, a gold medal has been awarded to the Roessler & Hasslacher Chemical Co. for their oxone exhibit at the Jamestown Exposition and a silver medal to Dr. Richard von Foregger of the same company for the exhibit of the process of regeneration of air by means of oxone.

The latter process, which was exhibited in practical use in the Radium Booth of the Government, is the same as was demonstrated by Dr. von Foregger at a local meeting of the American Electrochemical Society in New York, 1906, and at the general meeting of this Society in Ithaca, N. Y., reports on which were given space in this journal. Those experiments were made mainly for the purpose to supply an efficient and absolutely reliable means for the regeneration of air in submarine boats. The apparatus necessary for the working of this process was in the meantime worked out for other practical uses. The illustrations show the steps made from the first experimental apparatus to the present state.

The apparatus consists of two parts, a blower and a wire cage revolving in a cylinder. The wire cage contains the oxone, which, when the air is blown over same, undergoes that decomposition which produces the generation of oxygen and the absorption of carbon dioxide as well as toxic parts of exhalation, ordinarily termed "foulness of the air."

A short description which is found at the exhibit may illustrate the process:

"This apparatus is capable of regenerating the air in closed spaces. It automatically maintains the constitutional proportion of oxygen in air (in its normal percentage 20-21 per cent), absorbs all carbon dioxide and purifies. Under given conditions it thus preserves a healthy composition of the atmosphere."

It will not decrease the prevailing temperature, but will decrease the humidity, which renders the stay in higher temperature so unpleasant. This apparatus works at its highest efficiency when the conditions are most severe, *e. g.*, when the atmosphere, vitiated by animal breath, is entirely shut off from



FIG. 1.—OXONE APPARATUS.

the outside air, and also when the same is uninfluenced by any artificial change."

The last sentence in this description is comprehensible, when we consider that the grade of the decomposition of oxone depends on the amount of humidity furnished exclusively by the exhalations of those in the closed space. If this humidity has no other way out it is all bound to react upon oxone, which accounts for the automatical working of the process, *i. e.*, the more men contained in the room the greater the decomposition of oxone; there is a strict proportionality between the two factors.

Oxone, as everybody may know by this time, is electrically fused sodium peroxide containing a catalytic substance. The absorptive power of the caustic soda paste formed by the decomposition of oxone is not confined to the CO₂. Although not much is known about the great variety of toxic products of exhalation, experiments have shown that these organic

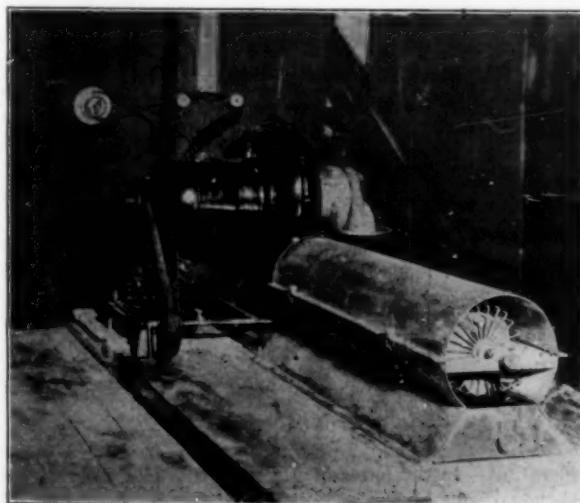


FIG. 2.—OXONE APPARATUS.

substances are either directly absorbed by the caustic soda or they are oxidized when coming in contact with the nascent oxygen on the surface of oxone; thus, bacteria is destroyed and odors are positively eliminated.

The latter property, the only superficial test by which the strange observer can go, was particularly remarkable in the dark room in Jamestown. Visitors of former years of the Government Radium Booth in the various expositions, according to many reports which were heard* and read, were agreeably pleased by the much improved conditions in this year's Radium Booth.

There was another little apparatus on exhibit, consisting of a 1/16-hp. electric fan motor, the fan only being 4 inches in diameter, and a device in front to hold a cylindrical cake of about 7 ounces of oxone. This apparatus, called "oxygator," is meant for office work, and should take the place of the regular fan motor during the winter months.

This process of regeneration of air, which we might term "internal ventilation," is, apart from its usefulness for hospitals, public rooms, work in mines, etc., very adapt for application in cold storage rooms. There the two propositions, to reduce humidity of the air to the utmost and to destroy or prevent germination, would be met with one function. Oxone has been and is being very successfully used in cold storage rooms for deodorization. This is done in a rather crude

Mr. Henry S. Blackmore, Judge Hough, sitting in the Circuit Court of the United States, Southern District of New York, has decided that Mr. Blackmore's reissued patents 11,995, of May 29, 1902, be revoked and declared null and void, because the reissue not only enlarged the claims of the original patent, but sought to cover an entirely different alleged invention. The Blackmore patent refers to the manufacture of sulphuric acid, and some of its claims are found to interfere with the contact-process patent of Knietsch, who is found to be the prior inventor. The Knietsch patent is owned by the General Chemical Co.

Dry Cells for Gas and Gasoline Engine Ignition.—The National Carbon Co., of Cleveland, Ohio, have just brought out a new dry cell, called the "red top" Columbia Ignitor. It is intended for gas and gasoline engine ignition on automobiles, motor boats, stationary engines, etc. On account of the special design for this purpose these cells are claimed to perform longer service than any other battery of corresponding size.

Combine of American and German Optical Works.—A great combine of three very important American and German optical manufacturing companies has just been effected. The Bausch & Lomb Optical Co. and the Bausch, Lomb, Saegmuller Co., both of Rochester, N. Y., and the Carl Zeiss Optical Works, of Jena, Germany, have joined interests for the purpose of carrying to the highest possible development the production of optical, physical and engineering instruments. As a result of this association the Bausch, Lomb, Saegmuller Co. joins the Bausch & Lomb Optical Co., and becomes an integral part of its organization, while the Carl Zeiss works maintain their entity at Jena, inasmuch as by their own articles of incorporation they are bound to exist in perpetuity, and at the same time they become members of the corpor-

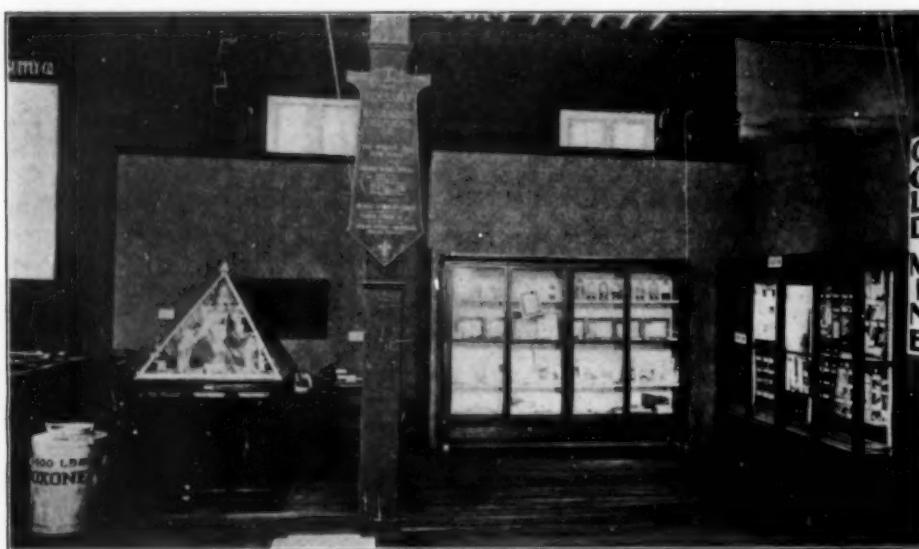


EXHIBIT OF ROESSLER & HASSSLACHER CHEMICAL CO. AT THE JAMESTOWN EXPOSITION.

manner by placing, according to the size of the room, a certain number of half-filled water buckets in the same, throwing into each a few pounds of oxone and closing the doors. After 24 hours bad odors coming from a half-year or a year's storage without ventilation have entirely vanished.

The exhibit shows the various cast shapes of oxone. It shows hydrone, the material which in a similar manner produces pure hydrogen gas upon contact with water. This is a lead sodium alloy. Other exhibits were the various peroxides and perborates, manufacture of which is partly done by the Niagara Electrochemical Works, of Niagara Falls, and partly by the Roessler & Hasslacher Chemical Co., of Perth Amboy, N. J.

Notes.

Erratum.—In the letter of Mr. Robert Sticht, published on page 302 of our last volume, the word "silica" should be substituted for silicon in the third line from the bottom.

The Crocker-Wheeler Co., of Ampere, N. J., have sent us a bound complete set of their bulletins. Among those of special interest to our readers are bulletins No. 83 (generators for electrolytic refineries), 84 (gas-engine driven alternating-current generators) and 85 (motors for rolling mills).

Patent Suit.—In the suit of the General Chemical Co. vs.

ate organization, Bausch & Lomb Optical Co. of Rochester, N. Y. The scientific staff, data, formulæ and magnificent inventions of Carl Zeiss, the excellent and enlightened business organization, scientific staff, experience and skill of the Bausch & Lomb Optical Co. and the inventions, experience and skill of the Geo. M. Saegmuller Co. have thus been united to give the scientific and engineering world optical, physical and engineering instruments and apparatus of the highest possible perfection.

A Limited Company for Electric Steel Plants.—The "Gesellschaft für Elektrostahlanlagen mit beschränkter Haftung, Berlin-Nonnendamm," is a union of the Eicher Hütten Verein, Le Gallais-Metz et Cie. in Dommeldingen, Engineer Paul Gredt, in Luxemburg, the Röchling Eisen und Stahlwerke, of Volklingen, the Metallurgiska Aktiebolaget in Stockholm and the Siemens-Halske A. G., in Berlin. This combination is to exploit the patents and patent applications owned by these companies, for the production of iron, steel and ferro-alloys, to exchange experience and grant licenses in all countries except Great Britain and its colonies, the United States, Sweden and Norway. The Swedish company named above remains the sole licensee in Sweden and Norway; the Gröndal-Kjellin Co. in London is sole licensee for Great Britain and its colonies and the United States. The manager of the new combination, Chief Engineer Victor Engelhardt, of the Siemens-Halske A. G.

The Brass Foundry.—A very interesting and suggestive paper was recently presented by Mr. W. S. Quigley before the New York Railway Club on "the brass foundry." The author pointed out how much the brass foundry has been neglected in the past and how much more efficient its operation can be made by modern methods of melting and handling metal. He referred to the radical change brought about by the introduction of the oil furnace. "It is an indisputable fact that the oil furnace is here to stay, is recognized as standard brass foundry equipment and as an economical and efficient melting machine. During the last four months the Rockwell Engineering Co. alone have sold seventeen double-chamber melting furnaces, with a nominal melting capacity of over 40 tons per day, and I have no doubt that the Hawley Down Draft Furnace Co. have sold furnaces comparing favorably with the above output." The author then gave a great many examples from actual practice, showing the good that can be done by modern methods, and especially the economy that can be obtained with the Rockwell double-chamber melting furnace.

Pennsylvania State College.—Mr. J. P. Jackson, professor of electrical engineering at the Pennsylvania State College, has been appointed by the board of trustees to the position of Dean of the School of Engineering.

American Peat Society.—The American Peat Society, to the formation of which we referred in our October issue, has the following officers for the first year: President, Dr. Joseph Hyde Pratt, State geologist of North Carolina; secretary, Julius Bordollo, Kingsbridge, New York City; treasurer, Henry G. Halloran, Postoffice box 1,816, Boston, Mass.; vice-presidents, M. R. Campbell, R. Ransome, C. G. Kleinstuck and Dr. J. McWilliams. The yearly membership fees are \$5 for active members and \$2 for associates.

American Electrochemical Society.—At the meeting of the board of directors, held in Philadelphia on Nov. 6, the following gentlemen were elected members: Dr. Howard D. Smith, Beloit College, Beloit, Wis.; William H. Bassett, the American Brass Co., Waterbury, Conn.; H. Clyde Snook, president, Roentgen Manufacturing Co., Philadelphia, Pa.; John Clement Bradley, American Brass Co., Waterbury, Conn.; Prof. Dr. F. Fichter, University of Basel, Switzerland; Wm. C. Geer, chief chemist, the B. F. Goodrich Co., Akron, Ohio; Dr. Georg Langbein, Koeniglich Saechische & Hofrath, Leipzig, Germany; Dr. Axel O. Appelberg, General Electric Co., Schenectady, N.Y.; Dr. Colin G. Fink, General Electric Co., Schenectady, N. Y.; Dr. Charles F. McKenna, chemical engineer, 155 West 91st Street, New York City; Amos G. Reeve, Oneida Community, Niagara Falls, N. Y.; Jasper Whiting, Rumford Falls, Me.; William D. Crumbie, United States Appraiser's Department, New York City; Edward J. Lavino, E. J. Lavino & Co., Philadelphia, Pa.; A. M. Williamson, International Acheson Graphite Co., Niagara Falls, N. Y.; A. Bernard Draeger, proprietor of the Draeger Works, Luebeck, Germany; Dr. C. H. Sharp, Electrical Testing Laboratories, New York City; Jacob Hasslacher, president the Roessler & Hasslacher Chemical Co., New York City; Count A. de Rivaberni, general manager, Comptoir International de Vente du Ferro-Silicium, Paris, France; Robert Deissler, civil engineer and patent attorney, Berlin, Germany; Frank Hemingway, manufacturing chemist, New York City; W. Ferris Hendry, Western Electric Co., New York City; Arthur J. Hudson, patent attorney, Cleveland, Ohio; George Morey, Jr., University of Minnesota, Minneapolis, Minn.; Judson G. Smull, New Jersey Zinc Co., Franklin Furnace, N. J.; Roland Calberla, electrochemical engineer, New York City; Prof. Alexander Krakau, Electrotechnical Institute, St. Petersburg, Russia. At the meeting of the board of directors, held in New York on Dec. 27, the following gentlemen were elected members: Dr. Lars William Ohlom, University of Finland, Helsingfors, Finland; John L. Polk, Rensselaer Polytechnic Institute, Troy, N. Y.; Prof. Dr. Kamejiro, Yoshikawa, Im-

perial University, Kyoto, Japan; Walter C. Smith, A. C., United States Metals Refining Co., Chrome, N. J.; John B. Lewis, University of Texas, Austin, Tex.; W. H. Erhart, vice-president, Charles Pfizer & Co., New York City; Robert H. Hartley, Hartley Building, Pittsburgh, Pa.; Hugo J. Wichmann, United States Food and Drug Inspection Laboratory, St. Paul, Minn.; Herbert A. Baker, American Can Co., Paulsboro, N. J.; Meyer Schamberg, chemist and mining engineer, Philadelphia, Pa.; Wilbur F. Hurlburt, American Electric Furnace Co., New York City; Johan Winsnes, Vadheim Elektrochem. Fabrik, Vadheim, Sogne, Norway; Frederick V. L. Hiorth, electrochemical engineer, Christiania, Norway; Lewis E. Saunders, Norton Emery Co., Niagara Falls, N. Y.; James M. Neil, technical chemist, Toronto, Can.; Dr. Franz H. Hirschland, manager, Goldschmidt Chemical Co., New York City; Prof. Arthur B. Lamb, New York University, New York City.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBIDE (Continued.)

No. 612,694, Oct. 18, 1898, Heinrich Aschermann, Cassell, Germany.

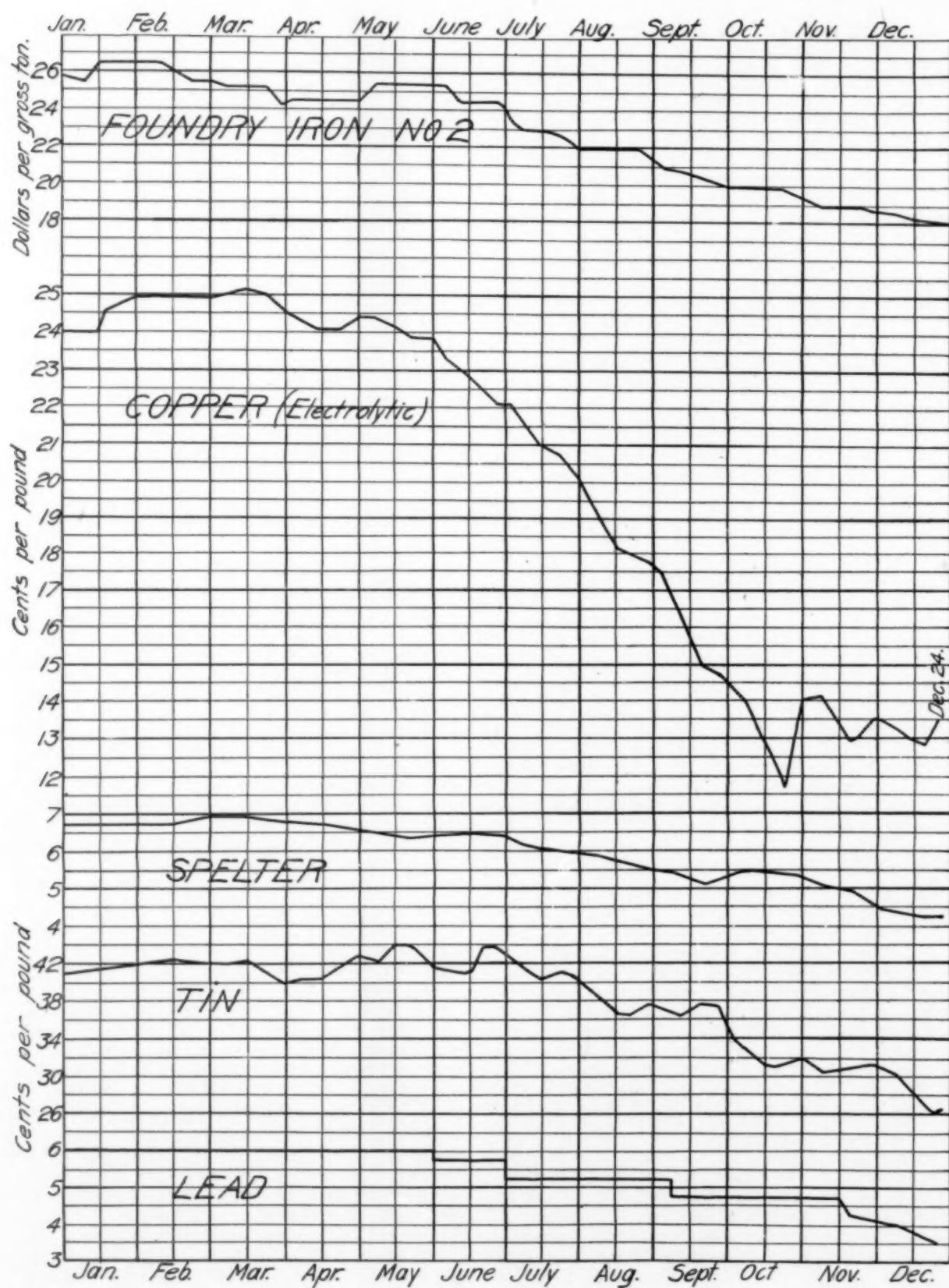
Simultaneously produces carbids and metals by electrolytically smelting a mixture of an oxid of one metal, a sulfid of a different metal and carbon. The carbon reduces both metals and combines with the one for which it has the greater affinity. The other reduced metal, if non-volatile, sinks to the bottom of the molten mass; if volatile, it is vaporized and condensed. For example: Smelts a mixture of iron pyrites, lime or limestone and carbon, producing calcium carbide, iron and sulfur dioxid. Alloys may be made by simultaneously reducing several metallic oxids or sulfids. Specifies a saving in electric current of 40 per cent.

No. 628,806, July 11, 1899, William Smith Horry, Sault Ste. Marie, Mich.

Smelts the charge by passing an electric current between the lower ends of depending parallel electrodes and through a pool of carbide beneath them and extending laterally beyond the field of reduction. The charge-mixture surrounds the electrodes and protects them from the air, being pre-heated by the escaping gases and retaining the heat. The carbide and charge-mixture and the electrodes are shifted vertically with respect to each other, to bring successive portions of the charge into the field of reduction. Three types of furnaces are shown. The first is an annular trough or wheel having removable casing-plates. The electrodes depend into one portion of the trough, which is gradually rotated to remove the pig of carbide from the zone of reduction. The second furnace has vertical metal walls and a bottom which is gradually moved downward as reduction proceeds, to carry the pig of carbide away from the zone of reduction. The third furnace consists of vertical, tubular superposed sections which are gradually moved downward, a section being added at the top as required.

No. 630,966, Aug. 15, 1899, Ludwig K. Böhm, N. Y. City.

Feeds charge downward through a tubular upper electrode consisting of a series of vertical carbon bars from 2 to 4 inches in diameter and 24 inches long, hold at the top in a copper ring casing. The lower electrode is a horizontal iron vessel, sliding on one iron plate. As this vessel fills with carbide, it is slid out and replaced by another. The bottom of the vessel is initially covered with a layer of carbide. The charge-feed is regulated by a rotating wheel. A central carbon bar may be placed in the upper electrode.



FLUCTUATIONS OF METAL PRICES DURING 1907.

(For explanation see page 4.)

NEW BOOKS.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS.—By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roeber, George Shaad. Twenty sections: units, circuits, instruments and measurements, central stations, transmission and distribution, illumination, electric traction, electrochemistry, telephony, telegraphy, miscellaneous applications of electricity, wiring standardization rules, tables and statistics. Bound in flexible morocco; over 1,300 pages, and 1,260 illustrations. Price, \$4.00 net, postpaid: New York: McGraw Publishing Co.

STEEL WORKS ANALYSIS.—By John Oliver Arnold and F. Ibbotson. Third edition, thoroughly revised and enlarged. 468 pages, 24 illustrations. Bound in cloth. Price, 10s. 6d. net. London: Whittaker & Co., and New York: Macmillan Co.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton. Illustrated. Bound in cloth. Price, \$3.00. New York: Hill Publishing Co.

SALDATURA AUTOGENE DEI METALLI.—By Prof. Ing. S. Ragni. 193 pages, 18 illustrations. Bound in cloth. Price, 2 lire (retail price in New York 50 cents). Milan, Italy: Ulrico Hoepli.

WESTERN BLUE BOOK AND BUYERS' REFERENCE.—Containing a complete classified list of all the constructional engineering, electrical, mechanical, mill, mining, foundry, iron, steel, quarry, machinery, railroad and kindred industries. Bound in cloth. Price, \$5.00. Chicago, Ill.: Milton E. Lowitz Publishing Co.

MINING, MINERAL AND GEOLOGICAL LAW.—By Charles H. Shamel. Over 600 pages, 100 illustrations. Bound in cloth. Price, \$5.00 postpaid. New York: Hill Publishing Co.

MATHEMATICAL HANDBOOK.—Containing the chief formulas of algebra, trigonometry, circular and hyperbolic functions, differential and integral calculus, and analytical geometry; together with mathematical tables. By Edwin Pliny Seaver. 288 pages. Bound in cloth. Price, \$2.50. New York: McGraw Publishing Co.

THE METRIC AND BRITISH SYSTEMS OF WEIGHTS, MEASURES AND COINAGE.—By F. Mollwo Perkin, Ph. D. 84 pages, 17 diagrams. Bound in cloth. Price, 1s. 6d. net. London: Whittaker & Co., and New York: Macmillan Co.

TURBINES, WATER AND STEAM.—By A. E. Tompkins. Illustrated. Bound in cloth. Price, \$1.50 net. New York: Edwin S. Gorham.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES.—By Ernest Sorel. Translated from the French by Sherman M. Woodward and J. Preston. 275 pages; illustrated. Bound in cloth. Price, \$3.00. New York: John Wiley & Sons.

THE BLACKSMITH'S GUIDE. Instructions on forging, welding, hardening, tempering, casehardening, annealing, coloring, brazing and general blacksmithing.—By Francis J. Sallows. 163 pages; illustrated by colored plates and diagrams. Bound in cloth. Price, \$1.50; leather binding, \$2.00. Brattleboro, Vt.: Technical Press.

GRAPHITE, ITS PROPERTIES, OCCURRENCE, REFINING AND USES.—By Fritz Cirkel. 307 pages, profusely illustrated. Bound in paper. Ottawa, Canada: Department of Mines, Mines Branch.

UNITED STATES GEOLOGICAL SURVEY:

Experimental work conducted by the chemical laboratory of the United States fuel-testing plant, St. Louis, January 1, 1905, to July 31, 1906. By N. W. Lord. 49 pages. A study of four hundred steaming tests made at the fuel-testing plant, St. Louis, Mo., 1904, 1905 and 1906. By L. P. Breckenridge. 106 pages.

The San Francisco earthquake and fire of April 18, 1906, and their effects on structures and structural materials.

By G. K. Gilbert, R. L. Humphrey, J. S. Sewell and Frank Soule. 170 pages, 57 plates.

Twenty-eighth annual report of the Director of the United States Geological Survey, George Otis Smith, director. 80 pages, 1 illustration.

Advance chapters from Mineral Resources of the United States for 1906, Washington, D. C.:

Summary of the Mineral Production of the United States in 1906. By William Taylor Thom. 57 pages.

The Production of Platinum in 1906. By David T. Day. 16 pages.

The Production of Mineral Paints in 1906. By Edwin C. Eckel. 12 pages.

The Production of Lime and Sand-Lime Brick in 1906. By Edwin C. Eckel. 11 pages.

The Production of Gold and Silver in 1906. By Waldemar Lindgren and others. 265 pages.

The Production of Copper in 1906. By L. C. Graton. 70 pages.

The Production of Zinc in 1906. By J. M. Boutwell. 35 pages.

BOOK REVIEWS.

THE CHEMISTRY OF COMMERCE. A simple interpretation of some new chemistry in its relation to modern industry. Robert Kennedy Duncan, Professor of Industrial Chemistry at the University of Kansas. Small 8vo.; 263 pages; 23 illustrations. Price, \$2.00. Harper & Bros., New York and London, 1907.

There is a breeziness about this book which suggests the wind-swept plains of Kansas; it abounds in puns, humorous touches, unexpected homely illustrations; it is as readable as Jules Verne and, moreover, is *not* fiction.

The twelve chapters are on Catalysis, Fixation of Nitrogen, the Rare Earths, High Temperatures, Glass Making, Industrial Alcohol, Floral Perfumes, Medicines, Microbe Inoculation, Cellulose and Industrial Fellowship. Taking the most electrochemical chapter, the fixation of nitrogen, it is handled as by a chemical and electrical expert; the latest discovery is there, explained in simple and yet accurate language. The same masterly grasp is apparent in all the chapters, combined with a most unusual ability to make clear to the non-technical reader. The technical reader, however, no matter how much he knows about the subject handled, will find the treatment interesting and very probably get new information or new ideas from it.

The final chapter deserves more than passing notice. The professor states what is undoubtedly true: "American manufacture is a chaos of confusion and waste. The confusion and waste, it should be said, are chemical, not mechanical. Along the lines of mechanical contrivances America need acknowledge no peer." The plea for the greater use of industrial chemistry is then pressed home with fervor. The point is made that chemists in the works, even when they are employed, are usually incapable of making all the progress which is possible, that they are often "killed by their own routine." A chemist may analyze, sensibly and accurately, the soda and lime and sand used in making glass, but he could not thereby determine the science of glass making; that kind of service was rendered by the professors from the University of Jena.

The manufacturer, the industrial chemist, the investigating chemist and the university professor must constitute the fellowship of interest and action necessary for the highest results. Such is the plan which has made Germany the scientific workshop of the world, the pattern for us as for all crude and wasteful butchers of Nature's prodigality. The manufacturers tried too long to get on without the chemist in their works, they have gone too long now without the co-operation of the

university. Industries with a particular difficulty to solve may, by combining, endow at very small expense a University Fellowship for original scientific work on their problem, and all the contributors share equally in the benefits attained. The young men holding such fellowships would become invaluable to the industry; in fact, should become its scientific leaders.

We heartily commend Prof. Duncan's book to all our readers. Its reading will be relaxation and improvement combined, pleasure and business, instruction and inspiration.

* * * * *

STEEL WORKS ANALYSIS. By Arnold and Ibbotson. Third edition; thoroughly revised and enlarged. 468 pages; 24 illustrations. Bound in cloth. Price, 10s. 6d. net. London: Whittaker & Co. New York: Macmillan Co.

The present edition of this standard British work on steel works analysis has 118 pages more than the edition of 1900. This increase has been made necessary by the growing complexity of the analytical problems presented to the analyst by the use, in special steels, of the elements vanadium, molybdenum, titanium, etc. New and more rapid methods are also given, and the section on gas analysis has been revised. The latest method for the calorimetry of fuels is fully described. A new feature of the book is the inclusion of methods for the analysis of bearing metals, brasses, bronzes and white metals. A brief chapter has been added on the analysis of high-speed steels.

The descriptions of methods are given with sufficient minuteness, and in nearly every case the reasons, theoretical and practical, underlying the methods, are given clearly enough to enlighten those whose training has not been of the broadest.

In a work in many respects so admirable and reliable it is surprising to find, under direct combustion of steel for carbon determination, the following recommendation to secure a sample sufficiently fine for successful combustion by the method given: "The drillings should, obviously, be as thin as possible. It is often possible from a packet of drillings submitted for analysis, to pass several grains through a sieve of 30 meshes to the linear inch, and this provides a most admirable sample."

It is well known to many that this is a most risky proceeding, for in many instances the finer portions of a sample of drillings are very materially higher in carbon, phosphorus, etc., than the coarser portions.

* * * * *

A MANUAL OF FIRE ASSAYING. Chas. H. Fulton, President of the South Dakota School of Mines. 8vo.; 178 pages; 44 illustrations. Price, \$2.00. New York: Hill Publishing Co.

Professor Fulton has been an assayer, superintendent of works, and is now professor of metallurgy; he, therefore, possesses the qualifications to write and speak with authority. He has put his experience, his learning and his personality into this book and made it one of the best guides to fire assaying yet produced. In the first chapter, on furnace and tools, we find at once the concise description, just criticism and valuable practical touches which are characteristic of the whole work.

One very important item, usually entirely ignored, is the continual reference to durability of apparatus and costs of operation, the latter reckoned out as so many cents per assay. Under the descriptions of fluxes, slags, reducing agents and operations, we find the chemistry of the assaying lucidly and accurately explained, so that the assayer may know exactly what he is doing instead of merely follow a set of rules. The discussion of slags is particularly modern. We commend the author for avoiding the awkward designations of ortho and meta-silicate, but cannot agree with him that $4\text{RO}_3\text{SiO}_4$ is the only sub-silicate; surely, the professor knows that it is not, but his readers would think that it was. A little more explanation of the "silica" or "quantivalent" ratio would have made matters clearer.

LANDAUER-TINGLE—Spectrum Analysis. 8vo, x+236 pages, 49 figures. Cloth, \$3.00. Second edition, rewritten.

TREADWELL-HALL—Analytical Chemistry. In two volumes. Vol. I. Qualitative Analysis. 8vo, x+466 pages. Cloth, \$3.00. Vol. II. Quantitative Analysis. 8vo, xii+654 pages, 96 figures. Cloth, \$4.00.

LODGE—Notes on Assaying and Metallurgical Laboratory Experiments. 8vo, viii+287 pages, illustrated. Cloth, \$3.00.

LE CHATELIER-BOUDOUARD-BURGESS—High-Temperature Measurements. Second edition, revised and enlarged. 12mo, xiv+341 pages, 79 figures. Cloth, \$3.00.

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The chapter on cupellation is probably the most illuminating treatment of this subject to be found in any work on assaying; there is no practical assayer but can learn considerable from it. Under the heading *Tellurium* the reason for the splitting up of the beads during cupellation—the lowering of the surface tension of the lead—escaped the author; the consideration of this fact (pointed out first by Dr. J. W. Richards) gives a very satisfactory explanation of the phenomenon and suggests methods of correction, such as the addition of antimony to such alloys to increase their surface tension during cupellation. The rest of the work, on parting, crucible assays, etc., is complete and full of originality. Altogether, the work is a breath of fresh air in a rather musty corner of the chemical laboratory, and is heartily recommended to all who wish to progress in assaying.

ANNUAIRE POUR L'AN, 1908. Published by the Bureau des Longitudes (Paris). 760 pages, with six appendices. Price, francs 1.50 (retail price in New York, 50 cents). Paris: Gauthier-Villars.

The present volume of this well-known excellent little French yearbook contains, besides astronomical tables (401 pages), compact tables relating to physics and chemistry, such as tables of densities, vapor tensions, specific heats, solubilities, electric units, etc. A chapter of 47 pages, prepared by Berthelot, and giving the most important thermochemical data in a very handy form, should prove specially attractive and useful.

THE METALLURGY OF THE COMMON METALS. Leonard S. Austin, Professor of Metallurgy and Ore-dressing, Michigan College of Mines. 8vo.; 407 pages (no index); 171 illustrations. Price, \$4.00. San Francisco: Mining and Scientific Press.

The title is misleading, in that only gold, silver, iron, copper, lead and zinc are considered; surely antimony, aluminium, nickel, mercury, platinum and tin are also common metals. But, as it is, the author has tried to cover too much ground in the space. All that is said is well said, but so much that is necessary to understanding it is left out, that the book can be of little use to a student who knows nothing of the subject, and is of less use to the practiced metallurgist who is tolerably familiar with his art.

In the seventy pages given to *Gold*, no description is given of hydraulicking or dredging, and we cannot agree with the author that these processes "belong rather to mining engineering than to metallurgy." Surely, any method by which a metal is extracted from an ore is a metallurgical process. The well-written forty-five pages on the cyanide process makes some amends. The short chapter on silver is similarly incomplete, because of the total omission of (even the name of) the *Patio* process; the rapidly increasing importance of cyaniding silver ores is not suitably recognized in the one short page given to it.

In the twenty-four pages given to the metallurgy of iron, there is no attempt made to describe anything but the manufacture of pig iron. Since this is farther from being iron *per se* than either steel or wrought iron, it is hard to see why one should have been described and the other two left unmentioned. The incompleteness of the book reaches its maximum at "Iron." Under *Zinc* no reason is given why the process has to be one of distillation, the boiling point of zinc not being even mentioned.

A final chapter of thirty pages, on commercial considerations, is fairly satisfactory. Throughout the work a commendable effort is made to introduce thermochemical data, and thus give some idea of the why and wherefore; it should have been modified, however, by the conditions under which the reactions take place, *e. g.*, at 1,050° in the metallurgy of zinc.

The reviewer's opinion is that the work is not an abridged

treatise on the common metals, such as its title would lead one to suppose, because it omits half of them; it is not even a complete review of the metallurgy of those metals which it takes up, for it omits altogether important processes, and in the case of iron, the larger part of its metallurgy. But what is written averages "good."

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THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION.

John B. C. Kershaw, F. I. C. 12mo., 68 pages, 24 illustrations. Price, 5 shillings. London: The Electrician Printing & Publishing Co., Ltd.

This is a reprint of a series of articles published in the *Iron Trade Review*, in 1906; also in *The Electrician* (London) at a later date. These articles have already been reviewed and criticised in our columns. Placing the whole together, in one volume, however, has certainly enhanced their value, and while the criticisms as to their sketchy nature and incompleteness are still true, yet, as a volume, they may be recommended as a welcome addition to the rather scanty literature yet extant on this subject in the English language.

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MATHEMATICAL HANDBOOK. Containing the brief formulas of algebra, trigonometry, circular and hyperbolic functions, differential and integral calculus and analytic geometry, together with mathematical tables. Selected and arranged by Edwin P. Seaver, A. M., LLB., formerly Assistant Professor of Mathematics in Harvard University. 279 pages. Price, \$2.50 net. New York: McGraw Publishing Co.

"The uses which this book may serve hardly need to be pointed out. Some years ago the author composed the part relating to trigonometry and used it as a syllabus for instruction in his college classes. It served its purpose and soon went out of print. But a stray copy of it found its way to the table of a well-known civil engineer, to whom it proved constantly useful, and by whom it was often referred to as 'his memory.' This engineer has suggested a revision and republication of the original book with important enlargements. Accordingly there have been added sections on algebra, the differential and integral calculus and analytic geometry. The subject of hyperbolic functions, which now receives much more attention than formerly, has been more fully treated. Tables have been added, which include not only those universally used, but also some—like those of the hyperbolic functions, of the natural logarithms of numbers, and that of the velocity of falling bodies ($v = \sqrt{gh}$)—that has been hitherto not readily accessible."

It seems to the reviewer that a book of this kind cannot do any harm, but can do very much good. Though nothing is more dangerous than the injudicious use of formulas, yet this book can hardly produce such an effect, since the explanations are so short that the formulas can hardly be applied by anybody who does not master the underlying principles and methods of calculation.

On the other hand, there is no necessity for anybody to know formulas by heart, if it is possible to look them up quickly; and the unnecessary loading up of the memory with a mass of formulas has contributed more than anything else to the regrettable fact that mathematics is simply distasteful to a great many logically thinking men. If this book will serve as the "mathematical memory" of its users, it will be useful.

The chapter on differential and integral calculus (44 pages) will be particularly useful to many. The integration of linear differential equations, differential equations of the second order and of differential equations of the n 'th order, with constant coefficients is given. If the author adds in a future edition those *partial* differential equations which are of fundamental importance in the potential theory, in the theory of heat and in mathematical physics in general, the value of this chapter to engineers would be considerably enhanced.

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